POWER

Vol. 39 NEW YORK, MAY 26, 1914 No. 21

Another Popular Misconception

"WHY, I THOUGHT ALL ENGINE ROOMS WERE DIRTY!"

Plant Serving St. Louis Railway Exchange Building

By Thomas Wilson

SYNOPSIS—A 2250-kw. plant supplying both alternating and direct current at five different voltages. Its special features are coal- and ash-handling equipment, the breeching arrangement and the noncondensing, single-stage turbines.

The Railway Exchange Building, of St. Louis, commonly referred to as the most spacious office edifice in the world, is a 22-story structure measuring 228x271 feet, and 308 feet high. The first seven floors are occupied by the Famous & Barr department store and the remainder is given over to railway and general offices. The total floor space aggregates 33 acres as compared to 25 acres for the Hudson Terminal Buildings of New York, and the contents are 15,500,000 cu.ft. against 13,000,000 for the Woolworth Building.

To furnish this enormous building with heat, light, power and refrigeration, are the chief functions of the latest power plant of the Cupples Station Light, Heat & Power Co., which is in the basement of the Kingston Building, over a block away. The plant also supplies a number of smaller business houses with heat, light and power. During the shopping hours the load averages from 1200 to 1400 kw., divided about half and half between light and power. A peculiarity of the service is that the electrical energy is both alternating and direct current, at three different voltages for the former and two for the latter. There are other interesting features, such as the coal- and ash-handling systems, steam outlets at the low end of the boilers and flow meters to measure the steam from each boiler, superheating tubes in the uptakes, special breeching arrangement, and single-stage, noncondensing turbines. The plant has a total of 2052 hp. in boilers, 2250 kw. in generating units, with pro-

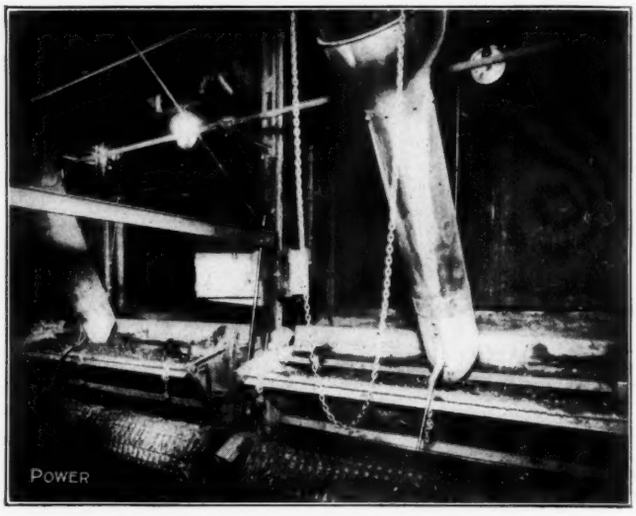


Fig. 2. Two of the Water-Tube Boilers

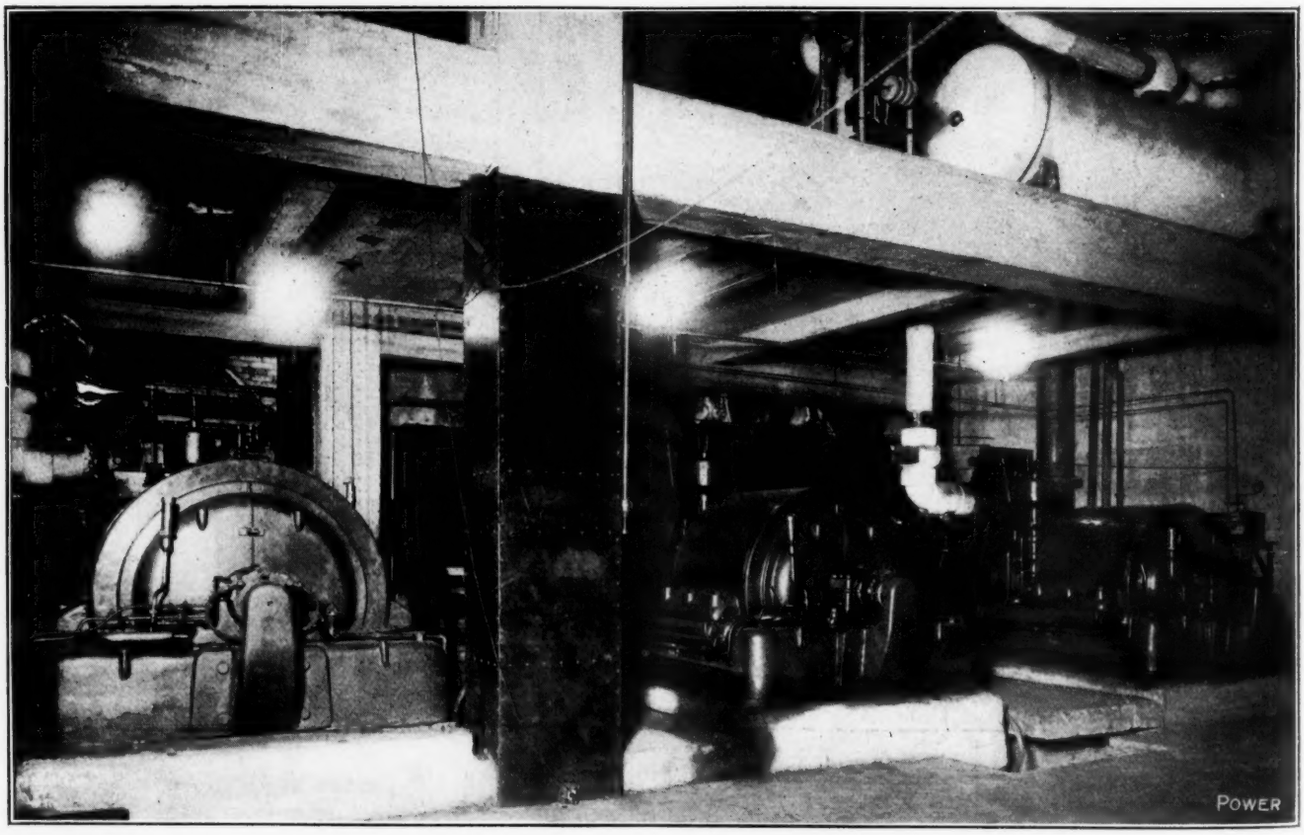


Fig. 1. The Three 750-Kw. Single-Stage Turbine Units

vision for an additional 750-kw., and 100 tons of refrigeration. It supplies exhaust steam for 250,000 sq.ft. of radiation during the day; live steam being used at nights in the colder weather. Steam under 40-lb. pressure is supplied for cooking purposes.

Boilers

There are four 513-hp. Heine boilers, Fig. 2, each containing 5134 sq.ft. of heating surface in two 42-in. drums, 22 ft. long and 296 tubes, 3½ in. in diameter. Green

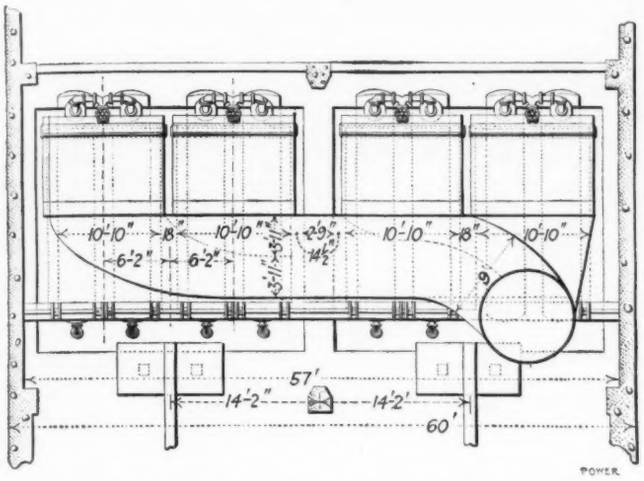


Fig. 3. Plan View of Boilers, Showing Breeching Arrangement

chain-grate stokers of the inclined type containing 110 sq.ft. of grate area serve the boilers, giving a ratio of grate to heating surface of 1 to 47. In each uptake is a Foster bare-tube superheater containing 1461 linear feet of 2-in. pipe, in which is a 1-in. core to force the steam to the outer wall and present a thin layer to the action of the gases. The superheater was designed to give 50 deg. of superheat with the steam at 200-lb. pressure and the entering flue gases at 600 deg. F. In operation, only 32 deg. of superheat has been obtained, but this is probably because the working pressure is 225 lb.

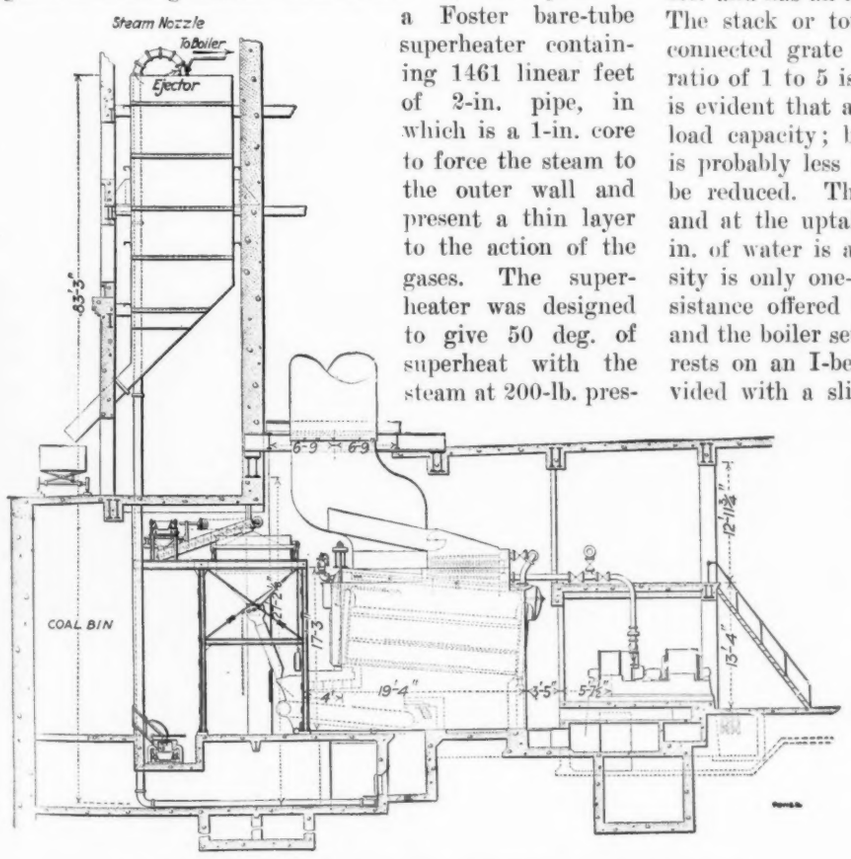


Fig. 4. Sectional Elevation through Boiler and Turbine Room

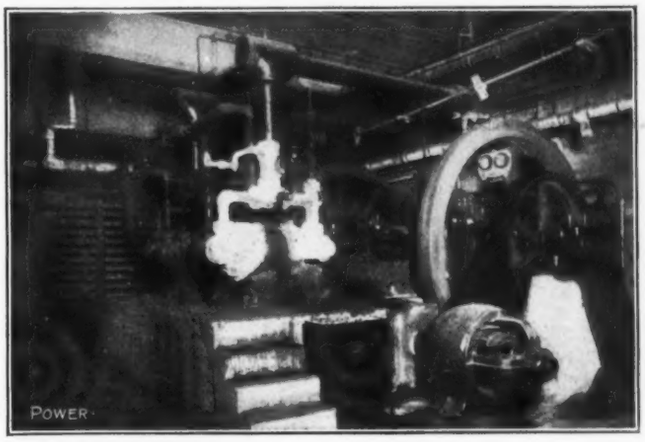


Fig. 5. Two 50-Ton Ammonia Compressors and Double-Pipe Condenser

and the flue gases do not exceed 550 deg. in temperature when the boilers are forced 50 per cent. above rating.

As shown in Fig. 3, the breeching has been made with easy curves and baffles have been so arranged that the gases from one boiler will not interfere with those from the boiler back of it. When the gases unite, they are flowing in the same direction and the area of the breeching has been proportionally increased. About 16 sq.ft. of breeching area per boiler has been provided, making a total of 64 sq.ft. at the stack which is 9 ft. in diameter and has an area approximating that of the breeching. The stack or total breeching area bears a ratio to the connected grate surface of 1 to 7. In good practice a ratio of 1 to 5 is common, so that in the present case, it is evident that ample provision has been made for overload capacity; besides, the effective area of each grate is probably less than 110 sq.ft., so that the ratio would be reduced. The stack rises 300 ft. above the grates, and at the uptake of the farthest boiler a draft of 1½ in. of water is available. Over the fire the draft intensity is only one-third of the above figure due to the resistance offered to the flow of gases by the superheater and the boiler setting. The steel stack is self supporting, rests on an I-beam frame work at the base and is provided with a slip guide tied into the steel work of the building at the roof. In front the boilers are suspended from I-beams, and at the rear rest on rollers held in place by a chair construction supported on brick piers.

A steam outlet at the low end of a Heine boiler is unusual and special precautions must be taken to obtain dry steam. In the present case a 6-in. dry pipe suspended from the shell is carried to the front of the drum, where steam is admitted through 100 one-inch holes bored in the top of the pipe. At the outlet a steam pot has been provided to receive any moisture carried along with the steam, and this is drained through a 1¼-in. pipe leading out of the drum. A deflecting

plate over the front water leg turns the circulation toward the rear and prevents any water in suspension from reaching the inlet.

Ordinarily, two boilers are required to carry the day load and at times three are necessary, leaving the fourth unit as a spare to be called into service at times of repair or cleaning. A feature is the installation in the steam line from each boiler of General Electric indicating flow meters. These instruments show what the boilers are doing at any time and indicate the proportion

Coal-Handling Equipment

Coal is delivered to the plant in wagons and dumped into a 250-ton bin in front of the boilers. As shown in Fig. 4, the coal falls from the bin by gravity into an Alvey Ferguson pivoted-bucket coal conveyor which carries the coal to the top of the boiler room and dumps it into individual screw conveyors delivering to seven-ton hoppers in front of each boiler. From this temporary storage, the coal is chuted to the stokers. The hoppers are mounted on scales with the indicating dial

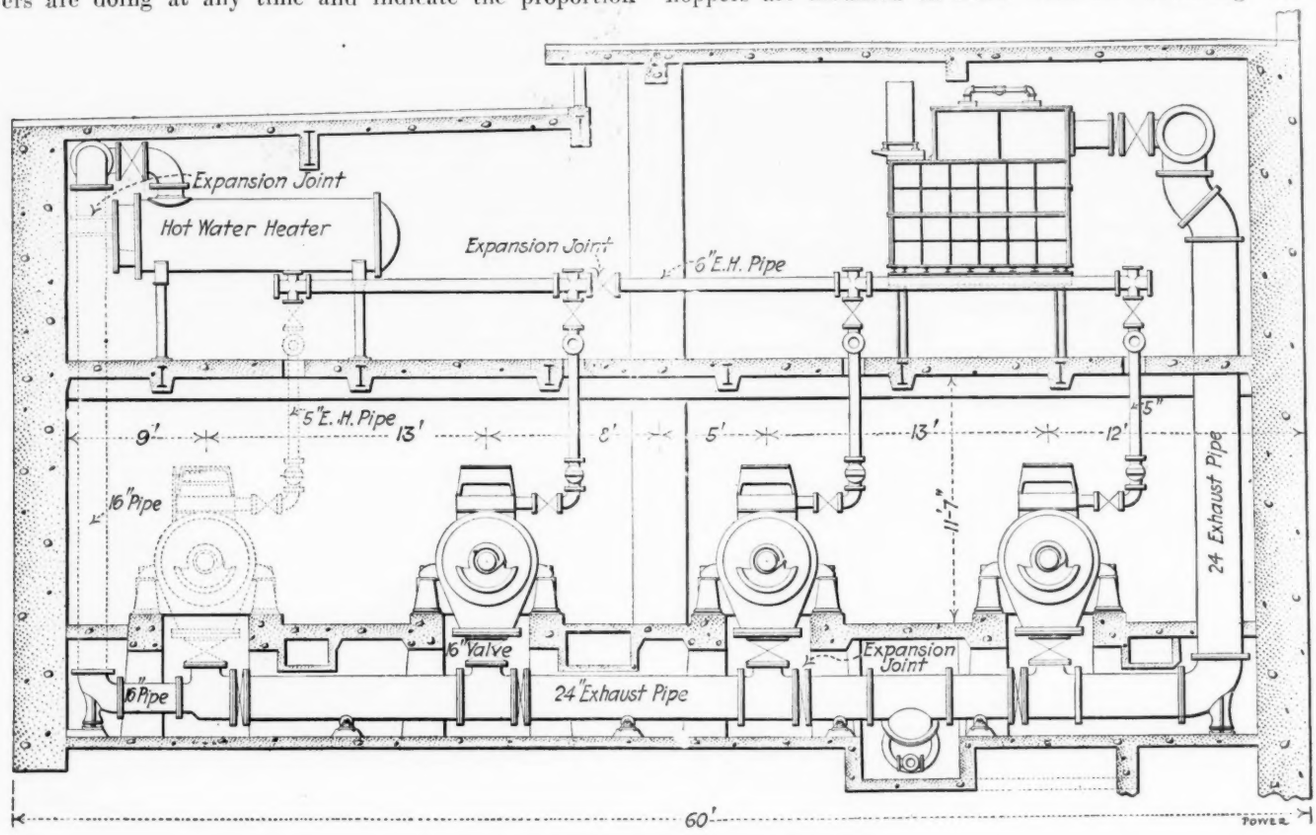


Fig. 6. Piping to and from Turbines

of the load each is carrying. The plant is also equipped with a 2000-hp. Cochrane heater with a V-notch and recording meter to measure the water fed to the boilers at a temperature of 210 to 212 deg. Centrifugal feed pumps are used, one being turbine driven and the other two connected to motors. The turbine unit has a capacity of 175 gal. per min., which is sufficient for the four boilers. Each of the motor-driven pumps has a capacity of 100 gal. per min. Ordinarily they are held as reserves, and are only put into service at times of light load when the demand is considerably below the capacity of the steam unit. Naturally, the piping is so arranged that any pump can supply any boiler.

carried down to a readable position. About 134,000 lb., 67 tons, of coal are burned per day. The fuel used at the present writing is 2-in. Illinois screenings not exceeding ten thousand B.t.u. per lb. Table 1, a consolidated report of the coal analyses for January and February, will give a good idea of the character of the coal.

To dispose of the ashes a Green pneumatic system was installed. This consists of a large ash tank extending from the second to the fifth floor of the building, an exhauster and dust collector on the roof and the necessary piping connecting the tanks to the furnace ashpits. An 18-in. galvanized-iron pipe connects the dust collector and exhauster with the ash tank. When the fan is in

TABLE 1. COAL TESTS FOR JANUARY AND FEBRUARY, 1914

Grade	Sampled at Date	Total Moisture Per Cent.	Moisture in Dried Sample Per Cent.	Volatile Matter Per Cent.	Fixed Carbon Per Cent.	Ash Per Cent.	Sulphur Per Cent.	B.t.u. as Fired per Lb.	B.t.u. Dry per Lb.
Washed screenings, No. 5	12-28-13	39.30	2.20	34.00	45.70	18.00	3.83	6,561	10,757
No. 4 screenings	1-14-14	15.83	3.70	37.90	44.40	14.00	3.70	10,062	11,701
2-in. nut	1-14-14	11.24	6.90	37.10	44.80	11.20	3.50	11,259	12,685
Unwashed screenings	1-30-14	13.37	4.20	31.60	38.00	26.20	6.51	8,001	9,047
Unwashed screenings	2-7-14	12.40	6.40	31.30	39.10	23.20	6.00	8,937	10,260
Unwashed screenings	2-7-14	14.80	4.90	33.60	38.10	23.40	4.80	8,796	10,318
Unwashed screenings	2-9-14	14.62	4.40	34.10	27.80	24.10	7.00	8,545	10,008
Unwashed screenings	2-10-14	12.54	6.70	30.40	37.20	25.70	5.50	8,123	9,288
Unwashed screenings	2-14-14	16.60	7.60	34.80	42.00	15.60	3.80	9,409	11,282
Unwashed screenings	2-19-14	17.00	4.90	34.30	39.50	21.30	7.36	8,507	10,248
Unwashed screenings	2-20-14	18.00	7.50	32.40	38.30	21.80	6.80	8,095	9,873
Unwashed screenings	2-25-14	15.00	5.20	31.60	39.30	23.90	5.30	7,650	9,000
Unwashed screenings	2-27-14	15.40	9.10	32.40	42.20	16.30	5.40	8,992	10,629
Unwashed screenings	2-28-14	14.00	7.20	32.80	42.90	17.10	5.00	9,162	10,654

operation a partial vacuum is created in the system and air at high velocity is drawn through the extra-heavy 6-in. pipe leading from the ashpits into the top of the tank. The ashes are scraped from the pits into ash pans through which they are introduced into the pipe and are carried along with the current of air. The tank has a capacity of 30 tons. In a system of this kind, the wear on the piping at the turns is excessive. The original installation had been provided with standard elbows, but later they were replaced with elbows of long radius to lessen the abrasive action of the ash. A Girtanner-Daviess ⅝-in. steam nozzle was also installed at the turn leading into the tank, the latter to serve in the same capacity as the exhauster. The original system was left intact, however, so that either the exhauster or the nozzle may be used. It is customary to place the nozzle at the lower turn in the pipe line so that part of the action is induced and part is positive. In the present case a lift of 90 ft. is effected by suction with equal satisfaction. The horizontal run is 75 ft. long, and the ashes from the farthest boiler travel 165 ft. before reaching the tank.

As the steam puts out the fire in the ashes and prevents clinkering, there is no trouble in removing them from storage. A chute leading from the bottom of the tank to the alley discharges the ash into wagons.

At present, the plant is equipped with three 750-kw. units consisting of single-stage, General Electric horizontal turbines driving directly at 3600 r.p.m. three-phase 60-cycle 250-volt generators, Fig. 1. Two units carry the load, leaving the third as a reserve. Provision has been made for the installation of a fourth of the same size as soon as the load makes this necessary. There are two 25-kw. exciter units, one steam-turbine driven and the other driven by a three-phase 250-volt induction motor.

The turbines are a modification of the usual two-stage type adapted to operate noncondensing. The casing is retained and the second stage removed. With nozzles proportioned differently for the new work, results much better than are ordinarily expected of a noncondensing turbine have been obtained. The rate guaranteed for 200 lb. initial pressure and atmospheric exhaust was 31.6 lb. per kw.-hr Under full load at the plant, the turbines have bettered this rate. At 200 lb. initial pressure, 1 lb. back pressure and 30 deg. of superheat, they have developed a kilowatt-hour on 31.2 lb. of steam. The consumption was measured by a General Electric recording flow meter which has been provided for testing purposes and for use on the live-steam line to the Railway Exchange Building.

A 6-in. lead from the superheating coils of each boiler runs 8 ft. horizontally to a tee reducing on the run to 5 in. to supply the turbine and discharging upward through the leg of the tee to a 6-in. header immediately above. A valve at each opening of the tee makes it possible for each boiler to supply a turbine directly or through the header either of the other turbines. A 5-in. supply pipe gives 0.026 sq.in. per kw. of rating and a 16-in. exhaust opening directly into a 24-in. main common to the other units gives 0.27 in. per kw. Fig. 6 shows the piping to and from the turbines.

The exhaust main supplies all the heating and is so valved that part of the exhaust of the main units, besides the exhaust from the auxiliaries, may be used in the feed-water heater or a hot-water heater for house service. Both heaters and the pumps are on a gallery

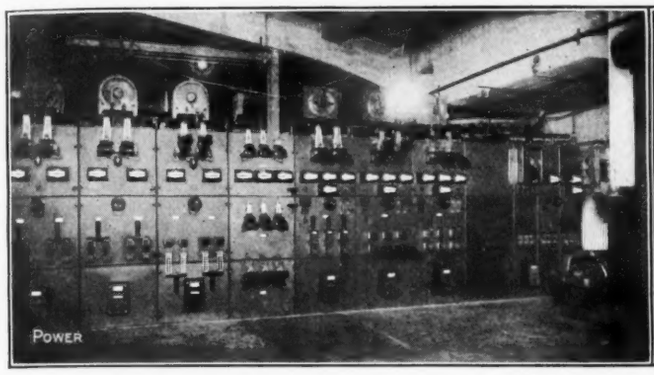


FIG. 7. ELEVEN-PANEL SWITCHBOARD

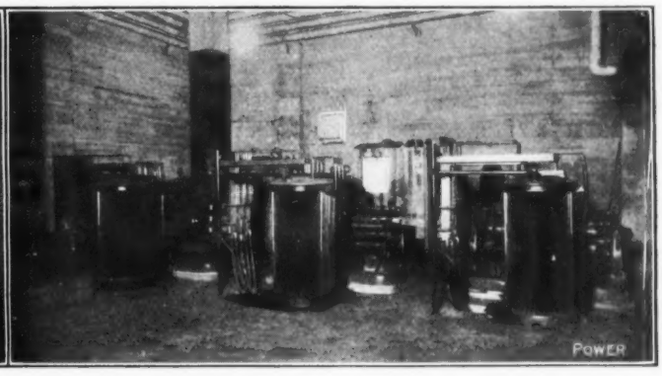


FIG. 8. TRANSFORMER AND ROTARY CONVERTER

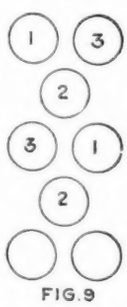


FIG. 9
Arrangement of Ducts
POWER

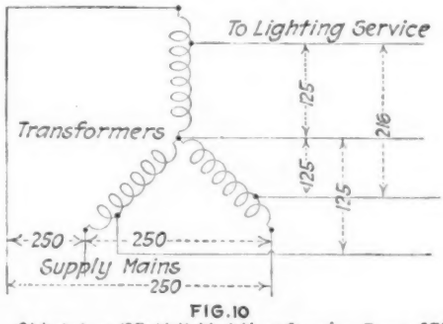


FIG. 10
Obtaining 125-Volt Lighting Service From 250-Volt Supply

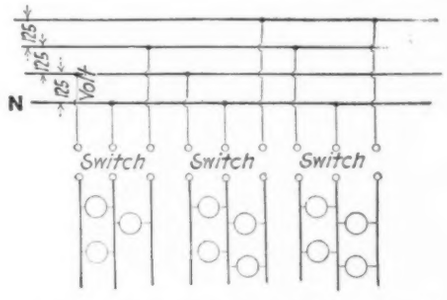


FIG. 11—Distribution of A.C. Lighting Circuits

CONDUITS AND WIRE ARRANGEMENT

above the turbines. In the Railway Exchange Building a Webster vacuum system is installed. Direct radiation is employed on the floors above the seventh and in the department store indirect radiation. The vacuum pumps, one steam-driven and the other motor-driven, are in the engine room. The smaller buildings served by the plant have gravity systems which put from 1 to 1½ lb. back pressure on the turbines. In addition, there is a 4-in. live-steam supply to the store for cooking and general restaurant purposes. This service is metered by a special General Electric indicating, integrating and recording instrument. At night high-pressure steam is supplied through a reducing pressure valve to the exhaust line for heating the building, as much as 30,000 lb. per hour being required in the colder weather.

Refrigeration is furnished to the store by two 50-ton Ruemmeli-Dawley compressors connected to 75-hp. mot-

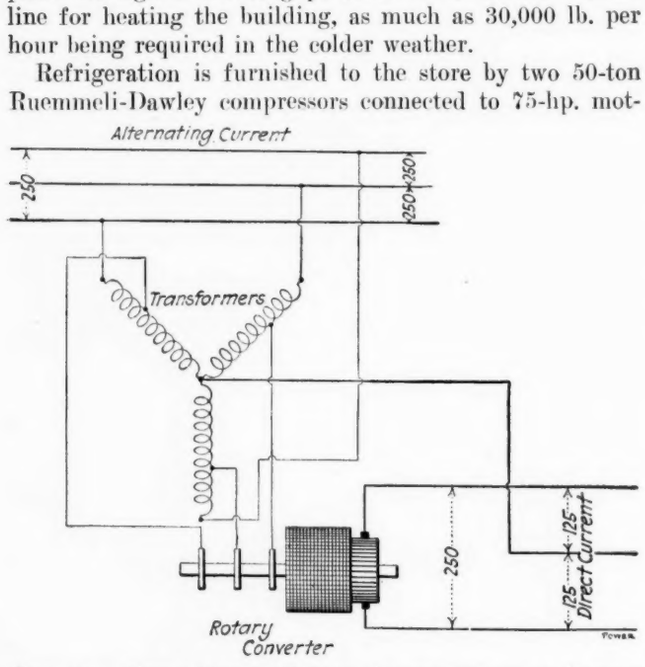


FIG. 12. FROM THREE-PHASE ALTERNATING TO DIRECT CURRENT AT 250 AND 125 VOLTS

ors by chain drives. The machines and the double-pipe ammonia condenser shown in Fig. 5 are in the plant, but the balance of the equipment is in the basement of the store. The liquid ammonia from the condenser and the returning vapor are therefore transmitted underground. The store is equipped with the brine system to tide over periods of nonoperation.

In the Railway Exchange Building there are a total of approximately 12,800 tungsten lights of 100 cp. each, supplied with 125-volt alternating current. A number of three-phase motors require three-phase alternating current at 250 volts and 38 elevators use direct current at 250 volts.

From the generators the three-phase 60-cycle, 250-volt current is carried to the switchboard, 75 ft. distant through six 2,000,000 circ.mils lead-covered cables, two per phase. The leads have been placed in 3½-in. individual fiber ducts spaced on 4-in. centers, and to overcome the induction which would naturally result from the high-amperage current, the phase circuits have been divided. The grouping of the ducts is shown in Fig. 9, the corresponding numbers indicating the two leads of each phase.

All of the alternating-current power service is three-phase, 250-volt and is used direct. The lighting service is three-phase, four-wire, 125-216 volts. Fig. 10 shows how these voltages are derived. The supply is brought to a three-phase autotransformer with the coils connected in star. Taps are brought out from each coil and between each of the taps and neutral, the voltage is 125. Across the phases on the service end the voltage is 216. The latter voltage might be used for power service. To balance the load between the phases, the lighting circuits in the Railway Exchange Building have been taken off as shown in Fig. 11.

Direct current at 250 volts is required for the elevator motors and 125-volt current for lighting outside of the Railway Exchange Building. This service is derived from the supply through autotransformers and rotary converters, three 300-kw. units being installed. As shown in Fig. 12, taps from the transformer coils lead to the rings of the rotary and 250-volt direct current is delivered from the other end. The neutral of each transformer is brought out and between it and either of the direct-current leads there is a difference of potential of 125 volts.

The plant has an emergency service connection with the Laclede Power Co., which is made through two 1000-kw. banks of transformers with star-connected primaries and secondaries arranged in delta. The voltage is stepped down from 4150 to 250 volts. This service is also used during the summer months, as the current is bought as cheaply as it could be produced in the plant without the benefits accruing from the heating load.

PLANT RECORDS

Daily reports are kept of the steam, coal and water consumption and meters on the various services record the electrical output. Table 2, a report for the month

TABLE 2. PLANT RECORDS FOR FEBRUARY

Kw.-hr. generated	365,600
Kw.-hr. sold, d. c.	167,761
Kw.-hr. sold, a. c.	149,615
Kw.-hr. sold, total	317,376
Ratio kw.-hr. sold to kw.-hr. generated, per cent	87
Kw.-hr. to rotary converters, a. c.	190,070
Rotary and transformer loss, kw.-hr.	22,309
Ratio of rotary d. c. to rotary a. c., per cent	88.3
Kw.-hr. used in plant	19,540
Kw.-hr. unaccounted for	6,375
Live steam to store for restaurant service, lb.	285,355
Coal, lb.	4,343,470
Ashes hauled, lb.	995,000
Water, cu.ft.	15,100
Coal for all purposes per kw.-hr. generated, lb.	11.9
Coal per kw.-hr. electrical load, estimated, lb.	7
B.t.u. per lb. of coal	6500 to 10,000
Make-up water, per kw.-hr., lb.	2.7

of February, will give some indication of what the plant is doing. The figure of 11.9 lb. of coal per kw.-hr. does not give a fair indication of the economy of the plant, as a considerable portion of the steam generated by the coal was used for heating and for operating boiler-feed and vacuum pumps and the ash-handling system. Separating these items from the total by means of detailed reports obtained in the plant reduces the coal per kilowatt-hour to approximately 7 lb. For a noncondensing plant using dirty coal of scarcely 10,000 B.t.u., the latter figure is not bad. The coal costs about 90c. per ton, and at a rate of 7 lb., this would give a fuel cost of 0.31c. per kilowatt-hr. It will be noticed that the ratio of kilowatt-hours sold to kilowatt-hours generated is 87 per cent. This difference of 13 per cent. is due to the rotary and transformer losses and to the use of nearly 20,000 kw.-hr. in the plant. There are only 6375 kw.-hr. unaccounted for in the month's operation.

Hugo Wurdack is president of the company, E. S. Billings is superintendent, and H. R. Mason is chief engineer of the plant. To Mr. Billings, we are indebted for much of the information contained in this article.

Purchasing Boilers--II

By J. E. Terman

SYNOPSIS—How to calculate the size of tubes and the layout. Design of boiler shell, and bracing, how the boiler is to be installed and how to designate what trimmings are to be used.

The size of tube to be used to best advantage is hard to determine as there are many factors to be considered. Generally speaking, the longer the boiler the larger the tube that can be economically used. Three, 3½- and 4-in. tubes have become standard for horizontal-tubular boilers in this country, and all other sizes can be said to be exceptions. Boilers with large tubes or flues, say 6-in. or more in diameter, are often capable of greater evaporating capacity per square foot of heating surface than boilers using smaller tubes, but this gain in capacity is usually at the expense of efficiency. The two-flue boiler could not be excelled for its ability to carry an overload, but it was hard on the coal pile.

A large tube is advantageous where the fuel used causes much soot, which rapidly fouls the heating surfaces. Small tubes require a more intense draft than large ones, and this is a point to be considered in selecting a boiler for a plant already having a chimney.

The tube sheets, or heads, should be made of firebox steel with a tensile strength of from 50,000 to 65,000 lb. per sq.in. and the tube holes should be punched not less than ½ in. smaller than the finished hole and then reamed to size, or, better still, drill the tube holes in the solid plate.

Layout of Tubes

The tubes should not be too closely spaced for there is likely to be trouble from weakness of the bridges between the tube holes, the boiler will not steam freely, and there will also be difficulty in removing scale from between the tubes, especially next to the heads. The tubes should be spaced at least 1 in. apart, and should be arranged in straight vertical lines to permit cleaning and free liberation of steam. There should be sufficient height between the top of the tubes and the shell to allow of easy liberation of the steam so that it can be drawn from the boiler without carrying an undue amount of moisture with it.

As a large boiler liberates more steam per square foot of liberating surface, it requires a greater height above the tubes than would a small boiler. A boiler of, say, 48-in. in diameter should have a space of at least 18 in. between the top of the tubes and the shell; a 78-in. boiler should have about 27 to 30 in. The heights above the tubes for intermediate sizes should be in proportion.

To make a free-steaming boiler and one readily cleaned, there should be plenty of room between the tubes and the bottom of the shell and also at the side between the tubes and the shell, with a generous vertical aisle up the middle of the boiler between the tubes. While this aisle is generally made 2 in. wide, 3 in. is better. The tubes should not be placed nearer than 3 in. to the shell at the sides, and since the tube rows are straight and the shell curved, the average space will be considerably more than this.

Ample space at the sides affords proper facilities for cleaning as well as for circulation, and the importance of space at this point cannot be too strongly emphasized. The tubes should be beaded against the head on both ends; this is especially important on the rear head.

Bracing

The bracing of horizontal-tubular boilers is simple. That to be placed on the heads above the tubes is preferably of the solid, crow-foot type and made weldless, although good welded braces are safe when allowed the customary limit of 7500 lb. per sq.in. of net area as a maximum working load.

Gusset bracing is strong, but it is likely to become fouled with mud, which lodges between the gusset plates and makes proper inspection of the head impossible.

Through bracing should be avoided above the boiler tubes, since it interferes with their accessibility and may give trouble by loosening, particularly if the braces are of relatively small diameter. Below the tubes the through type of brace should be used, since it avoids the necessity of attaching brace pads to the shell where they are liable to cause trouble by overheating the shell plate immediately under the pads. The rear ends of through braces, below the tubes, should be pinned to crow-feet or pinned between angle irons riveted to the head.

Where angle irons are used, they should be arranged with a pipe washer 1 to 1½ in. long; placed over each rivet and between the angle iron and the head, to hold the angle iron away from the head, thus permitting the free circulation of water back of the angle iron. The front ends of the through rods should pass through the front head, using a nut on each side of the head and a cupped washer between the outer nut and the head of boiler for making a tight joint.

Boiler Shell

The shell of the boiler should be made of material of suitable thickness for the pressure desired; the minimum should be $\frac{5}{16}$ in. up to 54 in. sheet diameter and ⅜ in. thick above this size. The maximum thickness should not be over ⅝ in., and ½ in. or $\frac{9}{16}$ in. where scale is liable to become troublesome.

The seams should be of the butted and strapped type and either triple or quadruple riveted; for small boilers double riveting may be used. The rivet holes should be punched ¼ in. less than the finished hole and reamed to size after the straps and sheets are bolted in place, or the rivet holes can be drilled from the solid plate.

The ends of the plate forming the longitudinal seams should be pressed to the true circle of the boiler shell before the sheet is rolled. This is a feature that should always be specified. The butt straps should be formed to the true contour of the shell before the rivet holes are reamed or drilled. The girth seams should be single riveted and the different courses of the boiler prop-

erly fitted together, so that light calking is required to make the seams tight.

Heavy calking on the seams of a boiler should warrant its rejection, because it is a certain indication that the parts were not properly fitted together, and the result is trouble and a short life if the boiler is to be subjected to hard service. The shell should be constructed of firebox steel with a tensile strength of between 50,000 and 56,000 lb. per sq.in.; material of a higher strength is liable to be less ductile and not as well suited for boiler purposes.

All brackets, nozzles or lugs should preferably be of pressed steel as should the manhole reinforcement. It should be required that these parts be properly fitted to the shell before being riveted on. There should be a manhole in the front head below the tubes (except for small boilers) and a manhole above the tubes. That above the tubes is preferably placed in the top of the shell, but it may be in the rear head above the tubes if the surrounding conditions make that the most suitable place.

The courses of a boiler should not be much over 8 ft. long, but they should always be so arranged that a girth seam does not come over the bridgewall; in fact, a girth seam that is nearer than 18 in. of either side of the bridgewall is likely to give trouble, due to overheating of the plate.

Supports

The usual practice is to support a horizontal-tubular boiler on side lugs, resting on the brickwork. This is the cheapest arrangement yet devised for that purpose and it gives fairly satisfactory results, but if boilers are hung from I-beams, which are supported on columns independently of the brickwork, the installation is much improved and the life of the setting as well as the safety of the boiler are enhanced.

Hanging the boiler from beams which are supported on piers built on top of the setting walls is an improvement over the lug-supported boiler. Between $18 and $25 usually covers the additional expense for hanging a boiler in this way, instead of supporting it on side lugs.

Fronts

The front of a boiler is largely used to present a good appearance and to furnish a suitable means for attaching fire and ashpit door frames, which could not be attached to the brickwork as are the frames of the cleanout door.

Since the front usually furnishes a finished appearance to the setting, it should be designed to please the eye. The sectional plate-steel front is superior to cast-iron in appearance and is more serviceable in every way. Two fire-door openings are preferable for use on all except small boilers, say, under 48-in. diameter, but no door opening should be less than 16 to 18 in. wide and 15 in. high, so as not to interfere with the firing.

If a boiler is set with the overhanging type of front, which is the best type in many respects, it should be so designed that the boiler will be a sufficient height above the floor level to prevent the smoke-box extension from interfering with the fireman. It should be specified whether the fire-door arches and side pieces are to be furnished with the boiler and a description of the kind should be supplied by the bidder.

The fire and ashpit doors and frames should be of cast iron and made of sufficient depth and weight to prevent warping. A warped or cracked fire-door is not only unsightly, it is uneconomical. The cleanout door of the combustion chamber should have a clear opening of at least 18x18 in., and should be well fitted to the frame to prevent air leakage.

To plane or mill the edge of a door and its frame costs money, but unless they do fit, there will be a constant loss in efficiency during the operating life of the boiler. The cleanout doors and frames, like the fire-doors, should be designed with proper depth and weight to prevent warping. Bars or rods should be supplied by the boiler manufacturer to serve as lintels to hold up the brickwork over the cleanout door openings.

Grates, Arches, Etc.

The principal requirement for grates is to have the manufacturer specify the area to be furnished and the weight per square foot of grate surface. The amount of grate surface should be such that there is 1 sq.ft. to each 40 or 45 sq.ft. of boiler heating surface. About 40 per cent. of the grate surface should consist of air spaces (grate manufacturers usually claim about 50 per cent.), but measurements will show such claims to be unwarranted, because it is not practical to make a substantial or serviceable grate with that much air space.

The covering arches for the rear of the combustion chamber should be designed to rest against the boiler head and on the rear wall. Such arches are more durable. They also follow the movements of the boiler while expanding and contracting, thus aiding in keeping a tight connection to prevent air leakage at the back end of the boiler.

Trimmings

If real competition is desired in obtaining bids for boilers, there must be a distinct understanding as to the kind and quality of the trimmings to be furnished. The usual trimmings that are considered to be a part of the boiler contract are the steam gage, with the necessary connecting pipe and shutoff cock, safety valve, water column, water-gage glass and gage cocks, together with the piping between the water column and the boiler; the blowdown valve for the water column and the valves, if they are used, between the water column and the boiler.

Usually, chain pulls are provided for the water-gage valves, if these are of a type that can be arranged to operate from the floor. The boiler blowoff valve or cock is also usually furnished, and usually the piping to attach it to the boiler.

The steam gage should be of sufficient size to permit its indications being readily observed from the boiler-room floor, and an 8- or 10-in. face is a proper size. The maximum graduation of the gage should be at least 50 per cent. above the intended working pressure in order to secure accuracy and long life, and to permit a hydrostatic test of the standard amount being recorded. The pipe connecting the steam gage to the boiler should be of brass and not less than ¼ in. in size. Iron pipe is likely to clog with rust scale.

The pipe connecting the steam gage to the boiler should be formed into a goose-neck, unless the location of the gage is such that water will always be on the gage

spring without the introduction of such a device. If steam is kept in contact with the gage spring, the indications are inaccurate, and the spring will be ruined. Similarly, heat transmitted from outside the gage is detrimental and the location should be such that it is exposed only to the normal room temperatures. The front of the breeching or upper portion of the boiler front is a poor location for the gage, unless it is insulated from the heat given off by these parts. The make and style as well as the size of a gage should be specified.

The safety valve should be of the spring-loaded type and the size should be specified as well as the make and style. If there are no laws to govern the size of the safety valve to be specified, all needs for safety will be complied with by calling for 1 sq.in. of safety-valve area for every 2 sq.ft. of grate area or each 100 sq.ft. of heating surface. There is a difference in price in safety valves, of about $25 on a 125-hp. boiler, so it is important that all bidders be on the same footing in this particular.

The water column is often made by the boiler manufacturer. If it is of good design, it can be accepted with his bid, but it is best to determine beforehand the kind of gage-cocks and water gages to be used. Then specify them, rather than try to differentiate between the kinds that will be offered by the manufacturers in submitting bids.

The piping between the water column and the boiler should not be less than 1¼ in. in size and crosses or tees should be specified in place of ells at points which will permit cleaning these connections by the removal of plugs in the unused outlets.

The pipe between the lower end of the water column and the boiler should be of brass as an aid in keeping the connections free.

The blowoff valve should be specified by the purchaser both as to size and style, since a considerable difference in price can be made by its use. The size of the blowoff should not exceed 2½ in., or be less than 2 in. for the horizontal-tubular boiler. It is practically impossible to give advice as to the style of blowoff valve to be specified, because there are so many types on the market which possess points of merit. It is best for the purchaser to choose one type so that all bidders will estimate on the one kind.

Specifications

While it is not practical for the average purchaser to write his own specifications, he can, in asking bids from manufacturers, request them to incorporate in their specifications the various features desired that are touched upon here, and the specifications which he will receive with the bids should be practically uniform.

If the purchaser desires to secure maximum efficiency in purchasing equipment, and is insured in a steam-boiler-insurance company, he can secure the desired specifications from it, and also the services of an inspector to watch the construction of his boilers, to see that the contract is properly carried out. These services are usually furnished free by the insurance companies.

The purchaser should bear in mind that in buying boilers, as in the purchase of other equipment, it is always best to deal with manufacturers who can be depended upon to stand back of their goods, even at a reasonable advance in price over the other fellow.

Dampers for Water-Tube Boilers*

By Osborn Monnett†

SYNOPSIS—Some radical improvements in damper design and arrangement which have added to the efficiency of water-tube boilers.

The damper, breeching and stack for a water-tube boiler should be designed to offer the least possible resistance to the gases. A damper ratio of 1 to 4, expressed in terms of grate surface, has given good satisfaction. As in horizontal return-tubular practice, this ratio is better obtained by approximating a square cross-section rather than by making the damper long and narrow. It is important that the damper obstructs the uptake as little as possible when standing open.

*Copyright, 1914, by Osborn Monnett.
†Smoke Inspector, City of Chicago.

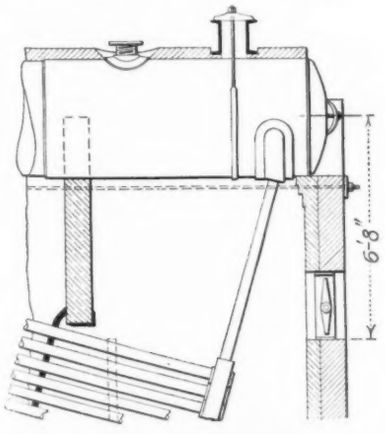


Fig. 1. Standard Rear-Wall Damper for Horizontal Water-Tube Boilers

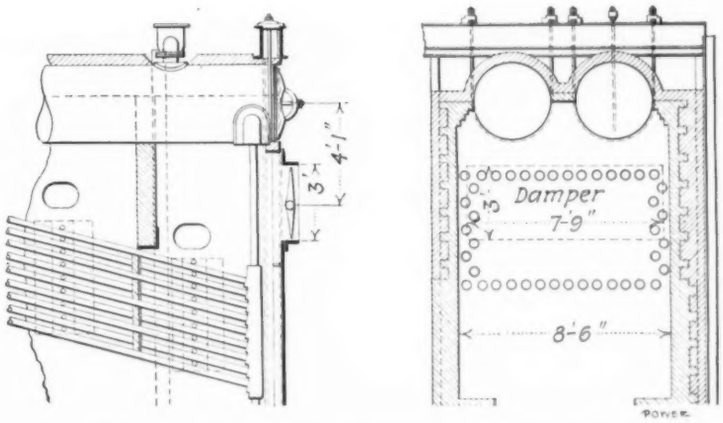


Fig. 2. Rear-Wall Damper of Later and Better Design

Characteristics of some of the different types of damper will be discussed. These types will be found to cover the ordinary makes of boiler on the market and can be modified to suit any installation with little or no change in general design.

Rear-Wall Damper

In the past this damper has been too small for high capacities. Fig. 1, an example of the older type, shows a damper much too small. This damper as usually installed does not extend the full width of the setting. Better results are obtained with the damper shown in Fig. 2, which extends across the boiler setting. There is less restriction to the gases and the capacity of the boiler is increased. In settings of this type the damper in any case should be made the full width of the setting as the circulating nipples restrict the available opening of the damper.

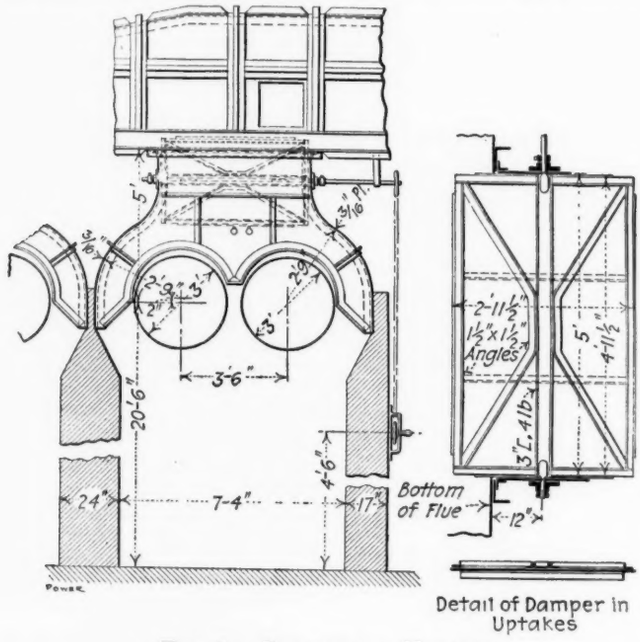


Fig. 3. Damper in Uptake

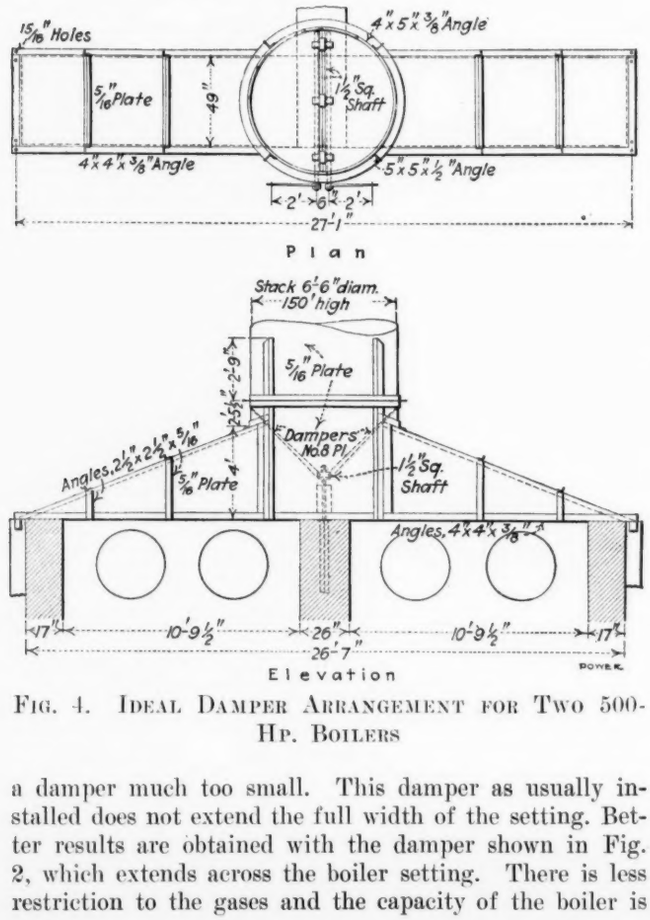


Fig. 4. Ideal Damper Arrangement for Two 500-Hp. Boilers

Damper in Top Connection

This is the ideal damper connection for a horizontal water-tube boiler. In Figs. 3 and 4 working drawings of dampers of this type are given showing how they may be installed with a minimum resistance to the flow of gases. In this type of damper care must be taken not to unduly restrict the space between the side walls and the drum. To avoid this the side walls are corbelled out, as shown in Fig. 3. The damper may be installed at this point or in the uptake above the boiler.

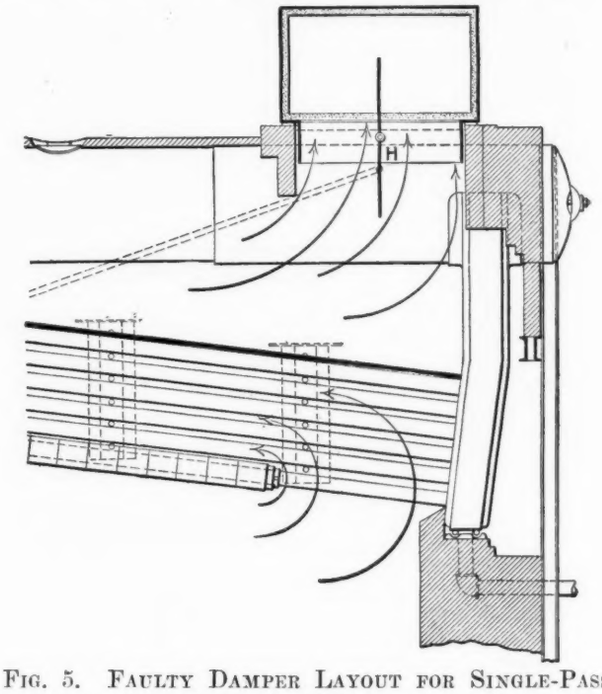


Fig. 5. Faulty Damper Layout for Single-Pass Boilers

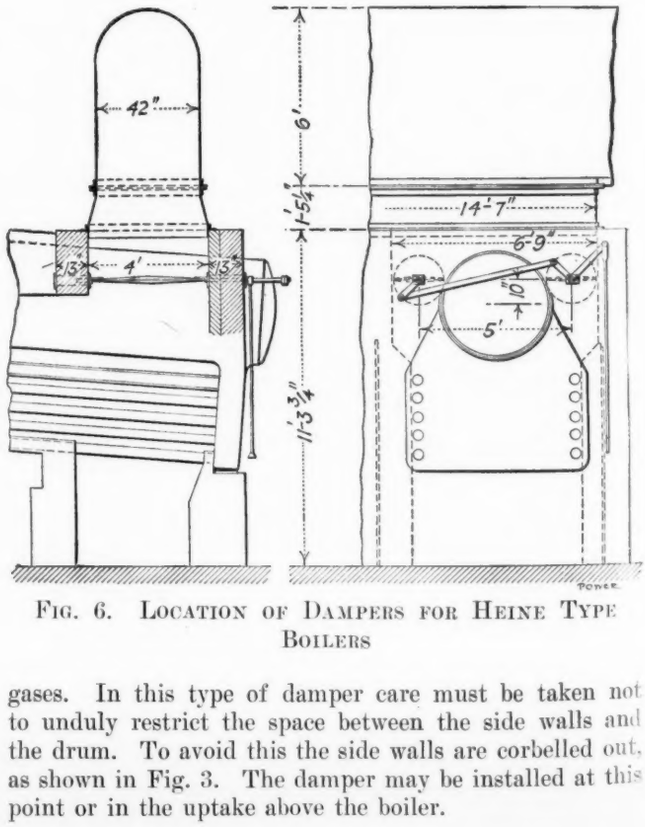


Fig. 6. Location of Dampers for Heine Type Boilers

The style of damper shown in Fig. 5 is faulty, as at best it interposes an obstruction to the flow of gases. Even with the damper wide open there is a neutral point at *H* which cuts off the effective area of the opening. Again, damper connections are not always tight and any lost motion in the joints or at the adjusting lever will cause the damper to hang out of center and restrict the uptake. This damper, then, should be avoided and the type shown in Fig. 6 substituted. Fig. 7 is a working drawing of the damper for a 350-hp. boiler. The dimen-

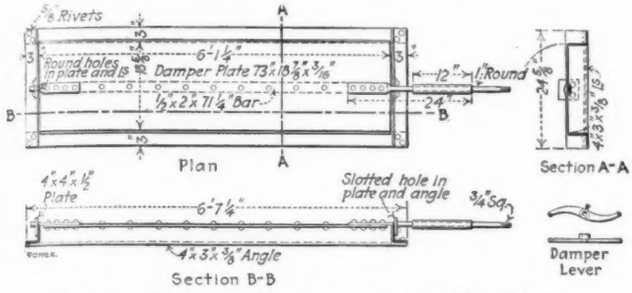


FIG. 7. DAMPER DETAIL FOR 350-HP. BOILER

sions can be varied to suit the size of boiler, using the same relative proportions and making the free opening one-fourth of the connected grate surface. The layout shown in Fig. 6 can be applied to any horizontal water-tube boiler. It permits a straight, uninterrupted flow of the gases into the stack.

STIRLING DAMPERS

The construction of this damper is necessarily long and narrow, and the space allotted to it is sometimes greatly restricted. The Stirling damper should be made as wide as possible. There are two types: The damper in the back wall, and the damper with top connection. One good and one bad installation of each type are shown in Figs. 8 to 11, with the third-pass baffle lowered to correspond with the ideas previously expressed. The best type of Stirling damper is that which provides the uptake on top with the wall corbelled out to give a maximum free opening.

DAMPER REGULATORS

When discussed strictly from the smoke standpoint, with high volatile Western coals, the average damper regulator is a trouble maker. On hand-fired installations it is practically impossible to use a damper regulator in territories where strict smoke ordinances are enforced. The damper may close without warning just after a heavy fire has been thrown into the furnace. Under these conditions the fire will smoulder and smoke before the fireman has become aware that the demand for steam has slackened.

On mechanically stoked plants the same trouble is likely to arise, although by careful attention to details, damper regulators have been installed with a fair degree of success. These have been arranged so that the stoker engine is slowed down as the steam goes up, before the damper is checked. Conversely, the damper opens before the stoker engine is again speeded up. No damper regulator should be installed under any circumstances with mechanical stokers, unless the above provisions are carried out.

Simple Method of Determining Hardness of Water

BY W. H. GEARE

According to statistics, most defects in steam boilers are due to scale and deposits, thus showing the importance of knowing the amount of scale-producing salts in feed water. To detect individual impurities in water is a rather troublesome job and as scale is caused by two or three chief impurities, the following is a good way for an engineer, with the aid of inexpensive apparatus, to estimate the amount of these scale-producing substances. Some scale forms when hard water is heated and is due to deposits of calcium and magnesium carbonates and calcium and magnesium sulphates. The former arise from temporary and the latter from permanent hardness.

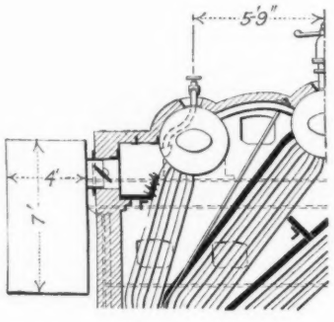


FIG. 8. POOR

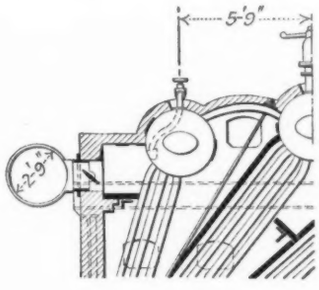


FIG. 9. GOOD

REAR-WALL CONNECTION FOR STIRLING BOILERS

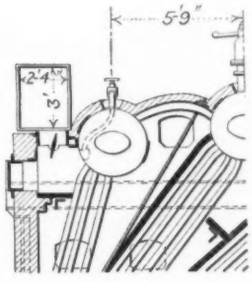


FIG. 10. POOR

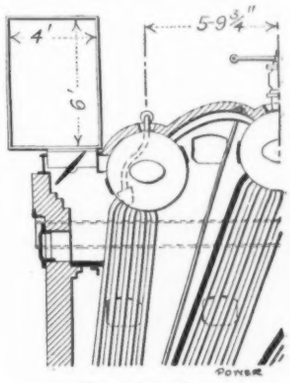


FIG. 11. GOOD

TOP CONNECTION FOR STIRLING BOILERS

In the first case, the salts are in solution as bicarbonates, which on boiling, lose the carbonic-acid gas and are converted into normal crystalline carbonates which are precipitated, the particles sticking to the side, forming scale. In the latter case, the salts are in solution as sulphates. These are not affected by boiling and the scale in this instance is formed simply by evaporation.

The total hardness is the amount due to both the temporary and permanent.

Both temporary and permanent hardness may be tried for, and the result will give the amount of impurities causing scale. A standard is adopted as "degrees of hardness" and is expressed as grains per gallon or parts by weight in 100,000.

The apparatus required consists of: 1 burette, 100 cu. cm. (c.c.) reading to tenths c.c.; 2 glass-stoppered bottles, 250 c.c. capacity; 1 flask, 500 c.c. capacity; 2 pipettes, 70 c.c. and 100 c.c. To estimate the impurities, secure the total hardness as follows: Get from any manufacturing chemist a standard soap solution. It is of such strength that 1 c.c. will neutralize 1 mg. or 0.001 gram of calcium carbonate (one solution that can be used is 15 grains of castile soap dissolved in 500 c.c. of alcohol and 500 c.c. of pure distilled water). Take a sample of the water and put 70 c.c. into each bottle. Now run from the burette containing soap solution a few cubic centimeters (say two or three at a time) into one of the bottles, shake it vigorously and lay on its side. If a lather does not appear, add more soap solution little by little until a slight lather appears on the surface of the water. At this stage, the soap solution should be added, two or three drops at a time. Allow the bottle to lie on its side for four minutes. If the lather breaks before the end of that time, add a little more solution, shaking the contents vigorously after each addition. When the lather stands or lasts for four minutes the test is done. The use of two bottles is to save time; while one is standing, the other can be in use, i.e., the soap solution may be added and shaken.

To calculate: 1 c.c. of soap solution equals 0.001 gram of calcium carbonate. Assume 70 c.c. of the sample were taken and say it required 8 c.c. of solution to produce the lather. Therefore, there are 8 grains of carbonates per gallon of water, which is 8 deg. of total hardness. If 100 c.c. of sample water had been taken then we would have had 0.008 gram per 100 grams of water (1 c.c. of water weighs 1 gram) or 8 parts per 100,000, also 8 deg. The total hardness of water expressed in degrees is as follows: 4 to 5 deg. is soft; 10 to 12 deg. is hard; 15 to 16 deg. is very hard.

To determine the permanent hardness due to the sulphates, simply boil the sample for half an hour (this will destroy the temporary hardness); then repeat the test, taking 70 c.c. or 100 c.c. as before.

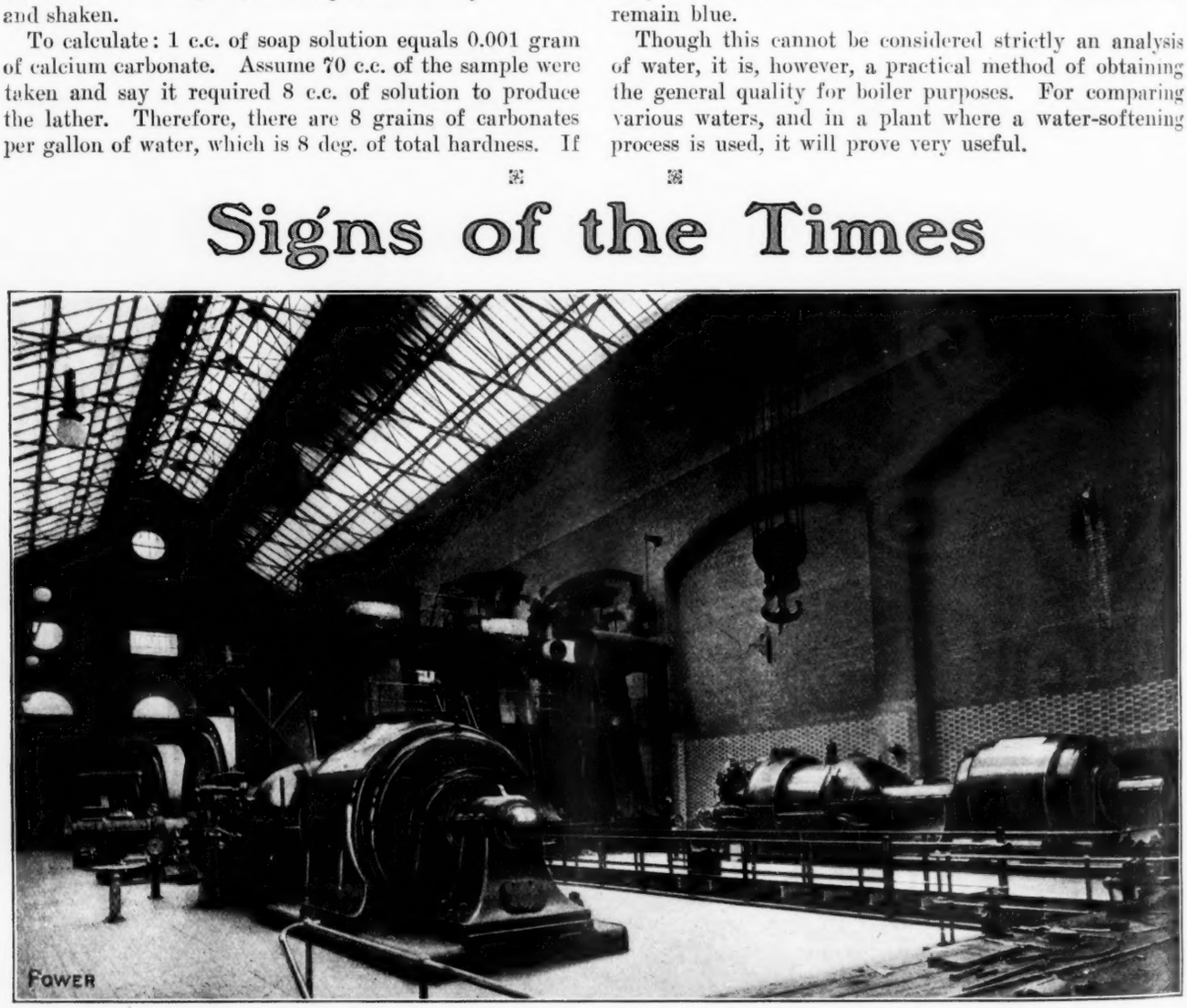
If more than 16 c.c. of solution are required to produce the lather, then dilute it to half its strength with pure distilled water, but be careful to double the result obtained. If very large quantities of calcium or magnesium salts are present, this method is not strictly correct, but is good for comparing different waters.

To get the amount of suspended matter causing sediment, simply filter 70 c.c. of sample water through a filter paper and weigh before and after; the weight in milligrams equals grains per gallon.

To find if the water is acid, hold a piece of red and blue litmus paper in the water for one-half hour. If acid is present, the blue will turn red and the red remain red; if it is alkaline the red will turn blue and the blue remain blue.

Though this cannot be considered strictly an analysis of water, it is, however, a practical method of obtaining the general quality for boiler purposes. For comparing various waters, and in a plant where a water-softening process is used, it will prove very useful.

Signs of the Times



THE TWO TURBINES IN THE FOREGROUND HAVE A CAPACITY EQUAL TO THAT OF THE WHOLE ROOMFUL OF ENGINES, OF WHICH THAT JUST BEHIND THE TURBINES IS SHOWN BEING DISMANTLED

From Central Station to Consumer

By F. McNeill

SYNOPSIS—A study in British thermal units of central-station service to a large isolated plant which has boilers for heating of more than sufficient capacity to generate the electrical load. A generating plant, it is estimated, would save about $40,000 per year.

The central-station and isolated-plant argument has reached a point where it behooves every engineer to give it unbiased consideration. If the central station can compete with the isolated plant successfully, the operating engineer should be the first to make the discovery, thereby deriving any benefits possible of the inevitable result of such a discovery. On the other hand, if it can be shown to the contrary, then such findings should be given all the publicity possible in order to offset some of the statements or misstatements, as would then be the case, that are now freely circulated by the central-station interests.

For instance, the central-station advocate has comparatively easy sailing when he is able to approach a prospective customer with the following statement, which is more misleading because it is half the truth, "We have as a customer one of the largest retail department stores in the city of Chicago who find it more profitable to deal with us than to operate their own plant." It is a fact that that there is such a store in Chicago and that it does buy its power from the central station, but by what intricate reasoning the management of that store arrives at the conclusion that it is saving money by so doing is beyond the writer's ability to discover.

The electrical power consumption at that store will run anywhere from 300,000 to 400,000 kw.-hr. per month. It has an elaborate boiler plant of 2100 hp. capacity, and is equipped with a refrigeration system of the absorption type.

It has been suggested that one of the reasons why this store does not operate its own generating plant is because the owners are interested in the concern furnishing them with power and light, so they virtually use their own product, and at the same time advertise their central station. This may or may not be true.

The engineers employed by the central station are fully aware of every loss, however slight, from the coal bin to the consumer. They must, therefore, be aware that the actual cost of production of heat, light, power and refrigeration is considerably greater than it would be were that power generated in the basement of the store.

Central stations throughout the country have been accused of fostering by rate discrimination just such propositions as the foregoing. How well the scheme works as an advertisement is shown by the large number of stores and office buildings that use central-station power. It is not possible for the managements to prove to themselves or to anyone that they are practicing economy; hence the only logical conclusion is that they are consumers of central-station power on account of rate discrimination, the misleading statements of the central-station solicitor, or they are victims of the class of advertising circulated by the average purveyor of electrical energy.

It is safe to say that the managers of the particular store under discussion would not have to think twice, in the event that central-station power was not available, before deciding that the place for their power plant would be in the basement of their store and not four or five miles distant, as is the case now. They would not have to employ consulting engineers to tell them that the apparatus for transmission and conversion of the power would cost almost, if not quite, as much as the proper machinery installed in their basement. It is quite probable that they would not install engines of the condensing type with all the auxiliary apparatus that would be necessary in order to get a high thermal efficiency, which would not exceed 15 per cent. at best. Engines of the single-expansion or possibly compound type, utilizing the exhaust for heating, refrigeration and ice making, would give good economy if the supply and demand for exhaust steam were anywhere near balanced.

That the enormous waste this one case represents in money as well as fuel may be better understood and appreciated, and that the reader may see the foregoing statements proved, the actual work being done will be converted into its equivalent heat value in British thermal units. A comparison will be made of the heat units expended under present conditions with the possibilities were the the engines and generators in the store.

One kilowatt-hour is equivalent to 3412 B.t.u. Assuming that the kilowatt-hour consumption per month is 300,000, the total useful work done would be equal to

$$300{,}000 \times 3412 = 1{,}023{,}600{,}000 \ B.t.u.$$

The central station in this case is equipped with the most efficient steam and electric-generating apparatus procurable. Boilers, however, are not discriminatory; they will do just as efficient work for an isolated plant as they will for a central station. For these comparisons an efficiency of 70 per cent. will be assumed in each case.

The prime movers in the central station are turbines operated condensing, and some of them are extremely large, with a test rate as low as 11.25 lb. per kw.-hr., not including the auxiliaries. Due to low load factors and standby losses, the average economy does not approach this figure. It is commonly stated that to produce a kilowatt-hour at the switchboard requires 30,000 B.t.u. Only 70 per cent. of this reaches the turbine, so that with steam at 200 lb. pressure and 200 deg. superheat, the average rate per kilowatt-hour would be

$$\frac{0.7 \times 30{,}000}{1309.7} = 16 \ lb. of \ steam$$

As the turbines and accessories use 16 lb. of this steam per kilowatt-hour, the heat units required for 1 kw.-hr. of output is

$$16 \times 1309.7 = 20{,}955 \ B.t.u.$$

and as 1 kw.-hr. is equal to 3412 B.t.u., the thermal efficiency would be

$$\frac{3412}{20{,}955} = 16.3 \ per \ cent.$$

The next loss sustained is that of the generator, which

may be assumed in both cases to be 5 per cent. The transmission loss is next; this is sustained by the central station alone. It is governed by the cost of copper and its installation. The question of installation cost in this case is so complex that a conservative estimate is rendered difficult. The wires are laid in expensive ducts, and many thousands of kilowatts are conducted over the same wires which are divided into a multitude of smaller circuits. It should be borne in mind, however, that the item is not small. The writer has been informed on good authority that the transmission loss allowed is 10 per cent., but to be on the safe side, a loss of 8 per cent. will be assumed. It does not matter how much power is transmitted over the lines, copper has to be provided for every ampere that flows. That is, there is no saving in copper on account of the large amount of power being transmitted. The same amount of copper is required to convey that power to the store as would be necessary were it the only current flowing.

The distance the current is transmitted is about four miles. It is transmitted at 9000 volts, three-phase, three-wire distribution, and is converted into direct current at a usable voltage by means of a rotary converter which, by the way, is not 100 per cent. efficient. A well designed converter of 1000 kw. capacity would have an efficiency of about 95 per cent. at full load. The current required to supply 1000 kw. at the end of the line, assuming the average power factor to be 0.90, would be

$$\frac{1{,}000{,}000}{9000 \times 1.732 \times 0.90} = 71 \textit{ amp. per main}$$

Assume that the power has a value at the end of the line of 1.5c. per kw.-hr. A transmission loss of 8 per cent. on 1000 kw. is 80 kw., and if that loss were sustained 10 hr. a day for 52 weeks of six days each, it would amount to 249,600 kw.-hr., which at 1.5c. would amount to $3744. This money would pay the interest and depreciation at the rate of 12½ per cent. on an investment of $29,952, which in itself would help materially in building a respectable isolated plant.

The size of conductor required would be No. 4, and the cost of 12 miles of this wire, making allowances for the fact that larger conductors are used, would be about $7000. These figures are derived from a quotation by a Chicago dealer. When the cost of the rotary converter is added to this amount, together with the maintenance cost, a sum of from $30,000 to $35,000 is represented. Adding to this the amount represented by the transmission loss would give a sum sufficient to install a generating plant which could compete successfully with any central station in operation today.

When one stops to think that this may be accomplished with the central station's waste, or at least with the losses that are an inseparable part of the central station but foreign to the isolated plant, one of the reasons why the former cannot long endure as a successful competitor to the latter is apparent.

For heating, about 160,000 sq.ft. of radiating surface is required. Under average conditions 100 sq.ft. of radiating surface will require one boiler horsepower, so that an installation of

$$\frac{160{,}000}{100} = 1600 \textit{ hp.}$$

would be necessary. On the assumption of full boiler capacity for 14 hr. a day and seven months during the year the annual coal consumption would figure out about 10,000 tons. Information emanating from a reliable source, however, gives 7250 tons as the average yearly consumption for heating the building, so that the latter figure will be used for final comparisons.

An expense borne by the isolated plant and not by the central station is the cartage cost of coal from the cars to the plant. Whatever that item is, the reader must remember that the coal now used for heating alone bears that expense, so the only difference is the cartage cost of the difference between the coal now used for heating and the amount that would be used for power and heating, which would be small.

With an isolated plant the boiler and generator efficiencies would be practically the same as those of the central station, so that it is only necessary to consider the engines. It is probable that two 800-hp., nonreleasing, four-valve engines would be selected for the work. A guarantee per indicated horsepower-hour of 22 lb. of saturated steam at 140 lb. absolute and 1 lb. back pressure can be obtained, although in practice the rate would be nearer 25 lb. The thermal efficiency of the engines in this case will differ from that of the turbines in that the turbines dissipate all of the heat energy in the steam delivered to them, for which they return 16.3 per cent. in the form of electrical energy, while the reciprocating machine of the isolated plant uses only a small part of the heat in the steam passing through it, rejecting the greater part as exhaust. The exhaust steam, however, has a thermal value of 100 per cent. for heating, ice making, etc.

Saturated steam at 140 lb. absolute has 1192.2 B.t.u. per lb. Between this pressure and 1 lb. gage, or, say, 16 lb. absolute, the engine will utilize only 158 B.t.u.; that is, this amount will be transformed into work. There will also be about 5 per cent. cylinder condensation, which will mean another drop of 60 B.t.u., or a total of 218 B.t.u. In every pound of steam the engine uses 218 B.t.u. and the balance, 974 B.t.u., is turned over to the heating or refrigerating systems.

As the engine uses 25 lb. of steam per indicated horsepower-hour, it requires

$$25 \times 218 = 5450 \textit{ B.t.u.}$$

for each indicated horsepower. To drive a 500-kw. generator of 95 per cent. efficiency, and allowing for 10 per cent. friction in the engine the latter would have to furnish

$$\frac{500}{0.90 \times 0.95 \times 0.746} = 783 \textit{ i.hp.}$$

In doing so it would use.

$$783 \times 5450 = 4{,}267{,}350 \textit{ B.t.u. per hr.}$$

The heat equivalent of 1 kw.-hr. is 3412 B.t.u. Therefore,

$$3412 \times 500 = 1{,}706{,}000 \textit{ B.t.u.}$$

is equivalent to the total useful work of the generator. Then considering that the exhaust is utilized, the thermal efficiency of the set would be

$$\frac{1{,}706{,}000}{4{,}267{,}350} = 0.399$$

or practically 40 per cent. It will be remembered that the thermal efficiency of the central-station unit, figured in the same way, was 16.3 per cent.

As there are two engines in use, each developing 783 i.hp. for 25 lb. of steam per i.hp.-hr., and 974 B.t.u. are rejected per pound of steam, then the boiler horsepower represented by the heat rejected by the engines is

$$\frac{2 \times 783 \times 25 \times 974}{33{,}479} = 1139$$

It will be remembered that a maximum of 1600 b.hp. is required for heating the building, so that all of this exhaust could be utilized for the greater part of the heating season; in other words, the total waste would be all of the exhaust steam five months of the year. No matter how much of the exhaust steam cannot be used, it is always available if required—that is, there is the equivalent of 1139 boiler horsepower of exhaust steam always ready for use wherever the 1600 boiler horsepower is now being used.

Assuming for the time being that all of the exhaust steam escapes to the atmosphere, the total heat used by the engines per hour would be

$$1192.2 \times 1566 \times 25 = 46{,}674{,}630 \ B.t.u.$$

During that hour the generators are supplying 1000 kw., which is equivalent to 3,412,000 B.t.u. The thermal efficiency of the units would then be

$$\frac{3{,}412{,}000}{46{,}674{,}630} = 0.073 = 7.3 \ per\ cent.$$

To the critic who will say that too much steam has been allowed for heating, the writer wishes to call attention to the fact that this particular store is equipped with a refrigeration system of the absorption type which could use not a little of the exhaust steam, and the large restaurant maintained by this store uses steam the year round.

The accompanying table compiled from the data given

COMPARISON BETWEEN CENTRAL-STATION AND ISOLATED-PLANT SERVICE

CENTRAL STATION FURNISHING POWER

Apportionment of work	Heat Value in B.t.u.
300,000 kw.-hr. per mo.	1,023,600,000
5 per cent. converter loss	53,873,684
8 per cent. transmission loss	93,693,363
83.7 per cent. engine and generator loss	6,013,906,866
30 per cent. boiler loss	3,079,317,392
7250 tons of coal used per yr. for heat	10,264,391,305
Average per mo.	13,288,000,000
Total	23,552,391,305

ISOLATED PLANT FURNISHING POWER

300,000 kw.-hr. per mo.	1,023,600,000
92.7 per cent. engine and generator loss	12,998,317,808
30 per cent. boiler loss	6,009,393,346
Average heat per mo. in addition to exhaust furnished	289,682,192
Total	20,320,993,346
Excess heat expended account of using central station power	3,231,397,959
Equivalent in tons of coal saved per mo. (11,000 b.t.u. per lb.)	147
Tons of coal saved per year	1764

in this article shows the difference in heat units between the two methods. Considering everything, the writer believes that if any advantages are given, the central station is most favored.

The table shows the saving in coal between the two methods, but not the saving that might be effected by installing an electric plant in the store. The item of profit to the central station must be considered.

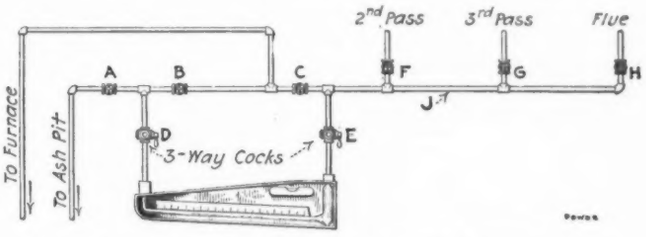
According to a schedule issued by the central station in question, the store has to pay 1.54c. per kw.-hr. for a maximum of 1000 kw. when the total amount used is 300,000 kw.-hr. per month. The monthly cost for power at that rate would be $4620. By referring to the table it will be seen that the total heat expended per month for heat, light and power by the isolated plant would be 20,320,993,346 B.t.u., and it now expends 13,288,000,000 B.t.u. for heat alone, a difference of 7,032,993,346 B.t.u., which represents 320 tons of coal.

It is the writer's candid opinion that no additional help would be required in this case with the possible exception of one fireman during the summer months. Allowing for this for six months at the rate of $80 per month, which would make an average of $40 per month for the year and 320 tons of coal at $2 per ton, the total additional cost would be $680 per month for power and light, for which the store now pays $4620, a difference of $3940. For 12 months this would amount to approximately $47,000, allowing for oil and supplies for the engines. The annual saving would very nearly install the generating units. The plant woould almost pay for itself in the first year, and deducting 12½ per cent. on the investment for interest and depreciation, would still leave an annual saving of about $40,000.

Draft-Gage Piping

BY D. MCGREGOR

[This article was published in the Apr. 14 issue, page 539, but the draft gage was shown connected wrong end to. That there may be no misunderstanding regarding the method of taking readings, the article is republished herewith with the gage properly connected.—EDITOR.]



PIPING AND VALVES FOR DRAFT-GAGE CONNECTIONS

The illustration shows how a boiler may be piped up to a differential-draft gage so as to give any desired reading. It is adaptable either to forced- or to natural-draft conditions, and requires some ¼-in. pipe and fittings, six straightway and two three-way cocks; the latter can be made out of regular cocks by drilling a small hole through the side of the cock and half way through the plug when set open.

Following is a list of the readings that may be had and how they are taken, supposing that all of the cocks are closed except those mentioned in each case:

1. For ashpit pressure, open *AD* straightway and *E* to the atmosphere.

2. For furnace pressure, open *BD* straightway and *E* to the atmosphere.

3. For furnace suction, open *CE* straightway and *D* to the atmosphere.

4. For drop through the fuel bed, open *A* and *C*, also *D* and *E* straightway.

5. For drop from ashpit to second pass, open *A* and *F*, also *D* and *E* straightway.

6. For drop from ashpit to third pass, open *A* and *G*, also *D* and *E* straightway.

7. For total available draft from ashpit to flue, open *A* and *H*, with *D* and *E* straightway.

8. For drop through boiler from furnace to second pass, open B and F, also D and E straightway.

9. For drop through boiler from furnace to third pass, open B and G, with D and E straightway.

10. For drop from furnace to flue, open B and H, with D and E straightway.

11. For draft at second pass, open D to atmosphere, E straightway and F.

12. For draft at third pass, open D to atmosphere, E straightway and G.

13. For draft in flue, open D to atmosphere, E straightway and H.

De Launty Gasoline Engine

For a number of years, O. M. De Launty, of Chicago, has been perfecting a two-cycle engine for automobile, marine and small power use in which crank-case suction and compression is replaced by a positive feed for the fuel, secured by the introduction of storage chambers and an enlargement of the engine piston at the lower end to form a pump for forcing the mixture to the combustion chamber.

The general arrangement of the engine is shown in the illustrations. Fig. 1 represents a four-cylinder engine of this type, and Fig. 2 represents diagrammatically a plan of two cylinders and the corresponding storage chambers. The engine is made up of two-cylinder units, which, as in the present case, may be duplicated if desired. The cranks are set 180 deg. apart so that when one cylinder is on the working stroke, the other is receiving and compressing the charge. As will be apparent in Fig. 1, the engine and pump pistons are concentric, and as both are one casting, they act in unison. The capacity of the pump is the volume contained between the engine piston and the cylinder walls of the pump when the combination piston is at the bottom of the stroke. Each pump serves the opposing cylinder.

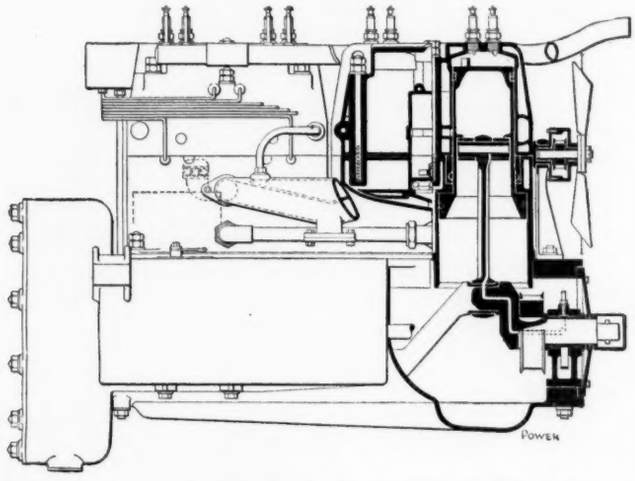


FIG. 1. SECTION THROUGH CYLINDER OF DE LAUNTY GASOLINE ENGINE

The cycle of operation may be traced in Fig. 2. The charge for cylinder A_4 is drawn from the carburetor through the inlet A_1 by the pump A_2 of the opposing cylinder. On the upstroke of this pump it is forced into the storage chamber A_3 and when the engine piston of A_4 uncovers the ports the charge flows into the cylinder, pushing ahead of it the burned gases through the exhaust A_5. Between the pump A_2 and the storage chamber A_3 there is a ball check valve, and a second one between the storage chamber and the cylinder. The cycle of operation for the other cylinder is the same, as indicated by the subfigures for B.

The pump capacity is about 10 per cent. greater than that of the engine cylinder and the volume of the storage

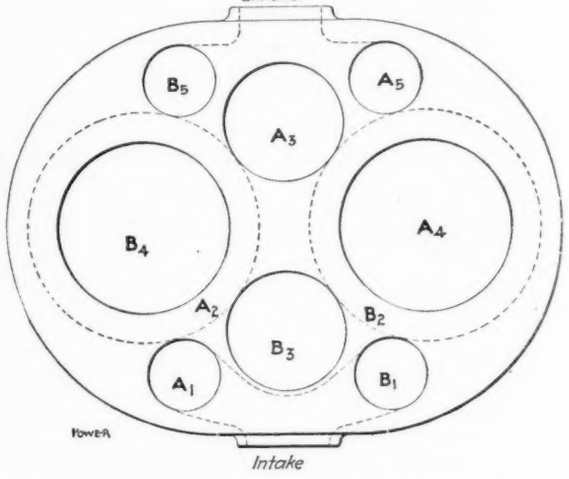


FIG. 2. PLAN SHOWING ARRANGEMENT OF CYLINDER AND STORAGE CHAMBERS

chamber is about 20 per cent. less. The chamber is large enough to receive the charge from the pump up to the point of admission of the opposing cylinder and store it at 4 lb. pressure. As admission occurs before the end of the stroke, the pump is still acting and forces a full charge into the cylinder. This is compressed to about 75 lb. in the engine cylinder.

In Fig. 1 it will be noticed that the engine piston has two rings, the pump piston one, and in the cylinder walls between the ports and the pump cylinder there is another. The ring last referred to is pushed inward by oil pressure to prevent any suction toward the pump cylinder and at the same time to lubricate the piston. The rubbing surface is greater than in the usual design, but the benefits secured from a full charge at each stroke should more than overbalance the excess in friction.

The maker is the De Launty Engine Co., 407 South Aberdeen St., Chicago, Ill.

Air-Tank Regulations—The Massachusetts Board of Boiler Rules has issued regulations to carry into effect a legislative act relative to the construction and inspection of tanks containing compressed air for use in operating pneumatic machinery. Tanks exceeding 18 in. in diameter and sustaining a pressure of more than 50 lb. per sq.in. must be inspected at least once in every two years by a state inspector, unless the tanks are inspected and insured by an authorized insurance company. The regulations cover the size, shape, construction, operation, maximum pressure and safety devices of such tanks.

Calculating Radiation for Steam and Hot-Water Heating

By Charles L. Hubbard

The square feet of direct radiation for a given room or building are found by dividing the total heat loss by transmission and leakage per hour, in B.t.u., by the efficiency of the type of radiator used. This simply allows for maintaining the normal temperature after the room is warmed. When the building is allowed to cool off at night, from 10 to 15 per cent. additional radiation should be provided, for quick warming in the morning.

Experience has shown that but little, if any, more fuel is required for warming a building continuously than when it is allowed to cool down at night. Although no heat is taken from the boiler when the radiation is shut off, the building and its contents are constantly giving out stored heat which must be replaced by forcing the plant before the rooms can again be raised to their normal temperature.

For this reason, the heat in large buildings is kept on for a part of the night, at least, to prevent the temperature from falling greatly. In cases of this kind it is not common to allow any additional capacity for "warming up," especially as the radiating surface is proportioned for the coldest weather and is, therefore, in excess of the requirements for most of the time. Furthermore, the lower temperature of the building adds to the efficiency of the radiation, thus increasing the power of the plant still more under these conditions.

Efficiency of Direct Radiation

The efficiency of a radiator depends upon the difference in temperature between the inclosed steam or water and the surrounding air, and also upon the velocity of the air passing over the heating surface. For the average conditions of direct heating the following rates of transmission may be used for different types of radiation. The variation is due to the form of surface, which affects the freedom of air flow as noted.

TABLE I.

Type of Radiation	B.t.u. given off per hr. per sq.ft. of surface per deg. difference in temperature between the radiator and surrounding air
Four-column radiators, 38 in. to 45 in. high	1.5
Three-column radiators, 38 in. to 45 in. high	1.6
Two-column radiators, 38 to 45 in. high	1.7
Three- and four-column radiators, 18 in. to 26 in. high	1.7
Wall radiators	1.8
Wall coils, 1 in. to 2 in. pipe	1.9

Assuming the temperature of the surrounding air as 70 deg., "working efficiencies" may be used for steam and water, as given in Tables 2 and 3 respectively.

TABLE 2. (STEAM)

Type of Direct Radiating Surface	B.t.u. given off per sq.ft. of surface per hr. 2 Lb. Gage Pressure	Atmospheric Pressure
Two-column radiators, 38 in. high	255	240
Wall radiators	270	255
Pipe coils	285	270

TABLE 3. (WATER)

Type of Direct Radiating Surface	B.t.u. given off per sq.ft. of surface per hr. for different average temperatures of water 170 deg.	180 deg.	200 deg.
Two-column radiators, 38 in. high	170	185	220
Wall radiators	180	200	235
Pipe coils	190	210	245

As a matter of fact, in computing the radiating surface for a system to be used in connection with a power plant, practically no difference is made in the amount furnished, whether for low-pressure gravity, vacuum steam, or forced hot water, although the efficiencies for the usual conditions are given in the tables as 255, 240 and 220 B.t.u. respectively.

While it is common to carry 2 to 5 lb. pressure in gravity plants using live steam, it is desirable in exhaust heating to reduce this to a point as low as is consistent with a proper discharge of air and of condensation against atmospheric pressure. As air venting and steam circulation are somewhat more positive with a vacuum system, the radiator efficiencies in each case are practically the same, although the pressure and the corresponding temperature is slightly less in the latter case.

Hot water, circulated at an average temperature of 200 deg., with a drop not exceeding 20 deg. (210 deg. to 190 deg.) will have an actual efficiency approximately equal to that of steam at atmospheric pressure, although the theoretical efficiency is somewhat less. This is due principally to the high velocity of the water flowing through the radiators, together with the entire freedom from air. When a live-steam heater is provided, initial water temperatures considerably higher may be employed if desired. In the earlier systems of forced hot-water heating, lower temperatures were carried, thus requiring larger radiators than for steam. Under the conditions of modern practice, efficiencies corresponding to those given for steam at atmospheric pressure in Table 2 may be used for all three classes of direct heating in connection with power work.

When a cast-iron radiator is concealed by grille work, the surface should be increased 25 per cent. and the openings so arranged that the air will circulate freely over it. Coils hung near the ceiling should be increased in size about 30 per cent. where it is desired to maintain a comfortable temperature near the floor.

Efficiency of Indirect Radiation

If it is simply desired to warm a room by indirect radiation, without reference to ventilation, the direct radiating surface may be computed and the result multiplied by 1.5. When definite conditions as to air temperature and volume are required, the following formulas may be used.

$$C = \frac{L \times 55}{(T - t)}$$

$$T = \frac{L \times 55}{C} + t$$

$$H = \frac{T \times C}{55}$$

in which

C = Cubic feet of air required per hour, at temperature T, to bring in the necessary heat (L) to warm the room;

L = Heat loss from the room, in B.t.u. per hour, due to transmission and leakage;

T = Required temperature of air supply (C) to warm the room to 70 deg.;

H = Heat required, in B.t.u. per hour, to raise the air supply (C) from outside temperature to that of admission (T);

t = Room temperature, commonly taken as 70 deg.

Example—The total heat loss from a room by transmission in zero weather is 30,000 B.t.u. per hour. The cubic content of the room is 12,000 ft., and it is desired to change the air four times per hour. What volume of air must be supplied, and at what temperature must it be admitted to warm the room to 70 deg.? What amount of indirect radiating surface will be required?

With indirect heating the loss due to *leakage* in buildings of first-class construction may be omitted when computing the total heat loss. The entering air, in this case, is warmed before it reaches the room, and the heat required for this purpose is included in that to be furnished by the indirect stack. When the building is poorly constructed, so that there is considerable inward leakage of cold air around the doors and windows, the heat loss by transmission should be multiplied by 1.1 to 1.2, according to local conditions.

Applying the preceding formulas to the present case, we have

$$C = 12{,}000 \times 4 = 48{,}000 \textit{ cu.ft. per hr.}$$

$$T = \frac{30{,}000 \times 55}{48{,}000} + 70 = 104 \textit{ deg.}$$

$$H = \frac{104 \times 48{,}000}{55} = 91{,}000 \textit{ B.t.u. in round numbers}$$

Having determined the value of H, the square feet of indirect radiation required to warm the room may be found by the equation

$$R = \frac{H}{E}$$

in which

R = Square feet of radiation;

E = Efficiency of radiator employed.

The value of E depends upon the temperature of the radiator, the average temperature of the air passing over it, and the velocity of flow.

With a velocity of 270 ft. per min., about 2.1 B.t.u. will be given off by the radiator per square foot of surface per hour, per degree difference between the *average* temperature of the air and that of the radiator. The average air temperature in the present case is

$$\frac{0 + 104}{2} = 52 \textit{ deg.}$$

Therefore, if steam at atmospheric pressure is used (212 deg.), the efficiency E will be

$$(212 - 52) \times 2.1 = 336 \textit{ B.t.u.}$$

For other velocities the efficiency will vary and may be computed by use of Table 4.

TABLE 4.

Velocity of air over heating surface, in ft. per min.	B.t.u. given off per hr. per sq.ft. of surface per deg. difference in temperature between the radiator and surrounding air.
150	1.54
200	1.82
250	2.02
300	2.22
350	2.42
400	2.60
450	2.72
500	2.81

Efficiency of Induction Heaters

Heaters of this type are often used in laundries, loft buildings, etc., where discharge ventilation is produced by means of a fan and the air supply is drawn in through heaters, due to the suction effect of the exhaust.

The conditions here are much the same as already described for indirect radiation, except that the velocity of the entering air is usually somewhat greater than in the case of gravity work, which increases the efficiency slightly. In the case of direct-indirect radiators of standard type, an efficiency of 2 B.t.u. per square foot of surface per hour per degree difference between the radiator and the average air temperature may be assumed, while with pin radiation and similar patterns, which break up the air currents more thoroughly, an efficiency of 2.3 B.t.u. may be used.

Example—A room 20 and 40 by 15 ft. has a heat loss, due to transmission, of 20,000 B.t.u. per hour in zero weather. Exhaust ventilation is to provide eight air changes per hour. What will be the required heating surface, in the form of direct-indirect radiators?

Applying the formulas as before,

$$C = 20 \times 40 \times 15 \times 8 = 96{,}000 \textit{ cu.ft. of air per hr.}$$

$$T = \frac{20{,}000 \times 55}{96{,}000} + 70 = 82 \textit{ deg.}$$

$$H = \frac{82 \times 96{,}000}{55} = 143{,}000+ \textit{ B.t.u.}$$

Average air temperature,

$$\frac{0 + 82}{2} = 41 \textit{ deg.}$$

Temperature of steam at atmospheric pressure, 220 deg.

$$E = (212 - 41) \times 2 = 342 \textit{ B.t.u.}$$

$$R = \frac{143{,}000}{342} = 418 \textit{ sq.ft. radiation}$$

In the case of laundries and loft buildings, the process is practically the same, except that direct radiation is commonly employed for heating and the induction stacks are used simply for ventilating purposes. In this case the required heat is determined directly by the formula

$$H = \frac{T \times C}{55}$$

in which T is commonly taken as 72 to 74 deg., unless a portion of the warming is also done by the induction heaters.

When ventilation only is required, an efficiency of

$$(212 - 31) \times 2.3 = 416 \textit{ B.t.u.}$$

per square foot of surface per hour may be allowed for pin radiation with steam at atmospheric pressure.

The British Coal Output—The British home office has issued an advance proof of the tables relating to the output of coal and other minerals in the United Kingdom during 1913. The output of coal, which was 260,398,578 tons in 1912, rose last year to 287,411,869 tons, the highest total on record. There were 1,127,890 persons employed at mines under the coal mines act, an increase of 38,800 on the previous year. The increase in the output of coal is 10.37 per cent., the increase in the number of persons employed is 3.56 per cent.

Correction: In the report of the lecture by Dr. William H. Walker, of the Massachusetts Institute of Technology, on "The Manufacture of Steel Pipe," on page 651 of the May 5 issue there is a misstatement. The sentence beginning on the last line of the first column should read "To produce one ton of iron in a blast furnace there are required approximately eight tons of air, two tons of ore, one ton of coke and one-half ton of limestone."

City Plant Started Up

After standing idle for nearly four years, or since its installation in 1910, the generating plant at Raymond Street jail, Brooklyn, was started May 13 in the presence of Commissioner Davis and several guests.

The plant is well laid out and consists principally of two 150-hp., B. & W. high-pressure boilers, one 100-kw. and one 75-kw., direct-current generators, each driven by a Harrisburg Fleming engine; a switchboard and the usual auxiliaries. At no time is the electrical load greater than the capacity of one generator, and when a blower has been provided, as is contemplated, one boiler should be able to carry the entire heating and electrical load, even in severe weather. Thus sufficient reserve capacity will be had and breakdown service will be unnecessary.

During the period that the plant was shut down the full operating force, consisting of a chief engineer, two assistants and three firemen, was retained. Therefore, the labor charges were going on just the same, as were also the investment charges, and it was necessary to have a boiler in service during the summer to provide steam for the kitchen, hot water for baths, etc.; yet the city paid the Brooklyn Edison Co. about 6c. per kilowatt-hour, while it could have produced its own electricity probably for ½c. per kilowatt-hour (exclusive of the items referred to, which went on anyway). While the exact amount paid out by the city for electricity during the time the plant was shut down is not readily obtainable, it is estimated that the city would have saved about $25,000 had it not shut down the plant.

Credit for starting the plant is due largely to C. G. Armstrong, consulting engineer for the city, Deputy Commissioner Lewis, and J. R. Coe, on behalf of the N. A. S. E.; also to Miss Davis, the Commissioner of Correction, whose insight into the economic aspect of the problem led her to take prompt action in the matter.

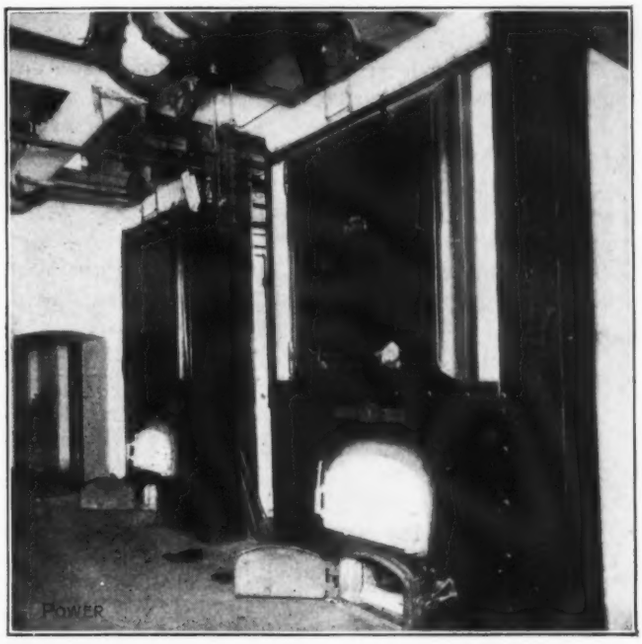


FIG. 2. BOILER ROOM

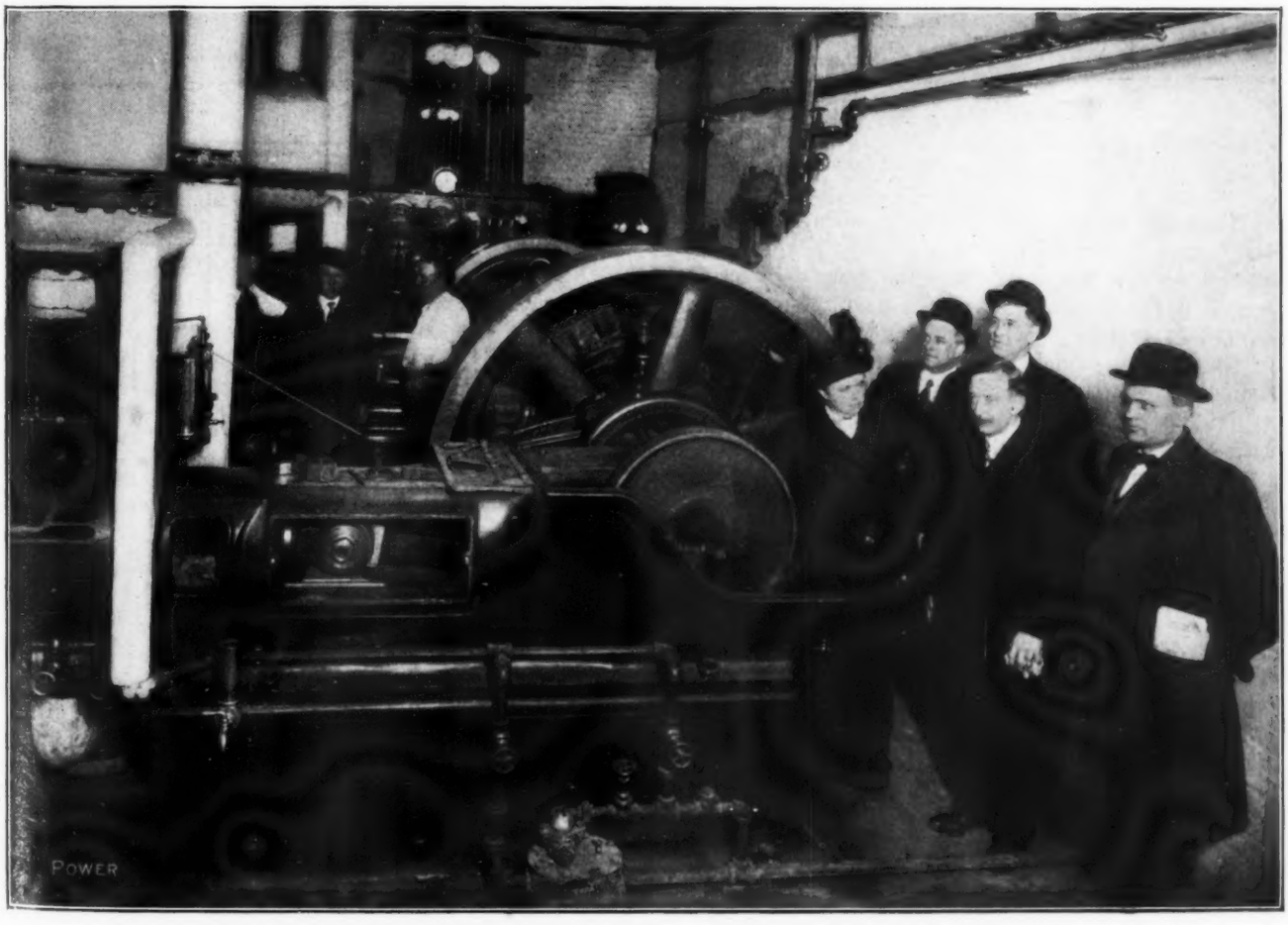


FIG. 1. ENGINE ROOM WITH COMMISSIONER DAVIS AND GUESTS PRESENT

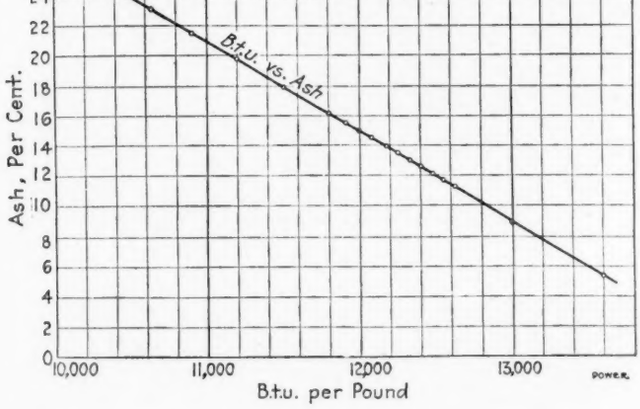
Hocking Valley Slack Coal

By Morgan B. Smith

SYNOPSIS—The relation which exists between heat value and ash content.

The writer has been aware for some time that there exists a definite relation between the heat value and the ash content of any given coal. This relation, when shown graphically by plotting the heat value vs. ash content, takes the form of a practically straight line, the ratio being inverse. The greater the heat value the lower the content of ash.

During the period June, 1, 1912, to Oct. 1, 1913, the writer had the supervision of the sampling and testing



Heat Value vs. Ash Content of Hocking Valley Slack Coal

of Hocking Valley slack coal representing in all some 1800 separate samples, many of which were monthly average samples made up from the daily car receipts at several power stations. The results of these tests, when plotted in graphic form, show a remarkable agreement in the relation which the heat value bears to the ash content of this particular coal. In fact, this relation is so definite that a chart made up as shown may be used as a check on the actual calorimetric determination or on the amount of ash contained in any given sample. Thus if the ash is determined the heat value may be read off the chart within a maximum error of from 10 to 50 B.t.u. compared with the actual calorimetric value determined in the ordinary bomb calorimeter.

The calorimeter used in these tests was the standard Atwater bomb apparatus. The bomb is gold lined with the exception of the lining of the top, which is of platinum. The thermometer used was a standard Bechmann differential, range 5.5 deg., furnished with the Deutsche Reichanstalt's certificate and also the certificate of the U. S. Bureau of Standards by whom it was checked. All samples were dried for one hour at 221 deg. F. in an electric oven before making the tests for heat value.

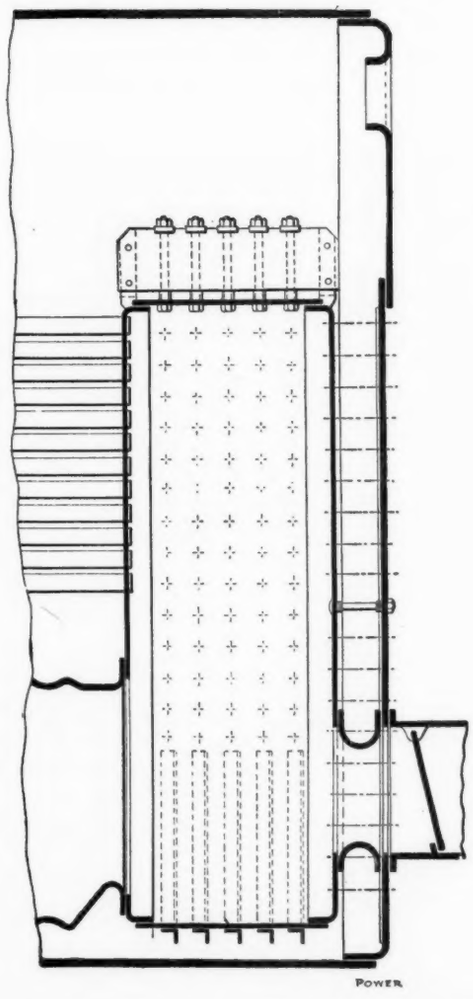
The ash determinations were made in a muffle furnace at a temperature of 1562 deg. F., the heating being continued until the samples came to a constant weight. No fluxing of the ash resulted in any of the samples with average sulphur content. Some samples in which the sulphur content reached a value of from 3.5 to 4 per cent showed fluxing in the furnace even at the moderate temperature employed, but these were very few.

The coal received is said to have been received from some 20 different mines so that the samples tested over so long a period must be representative of the general run of the coal available under the name "Hocking Valley slack." The average proximate analysis is as follows:

Fixed carbon, per cent.	52.60
Volatile, per cent.	34.20
Ash, per cent.	13.20
Av. sulphur, per cent.	1.80
Av. heat value, B.t.u. per lb.	12,300
Av. moisture in coal as received, per cent.	9.85

The writer has found the chart valuable for check purposes and is submitting it with the thought that it should prove equally valuable to other consumers of this coal.

A Safety Suggestion



Suggested Opening in Back of Marine Boiler to Allow Escape of Steam in Case of Tube or Sheet Failures. (See First Editorial)

Editorials

The Explosion Aboard the "Jefferson"

Added to the long list of the fatalities of the sea is the boiler explosion aboard the Old Dominion liner "Jefferson" off Cape Henry on the night of May 11, with its awful toll of eleven dead. This is a repetition of those grewsome accidents aboard the "St. Paul," "Delaware," "Bennington," "Sonoma," "Alamo," "Principe de Piedmonte" and many others.

Worse than rats in a trap, these unfortunates in the fifteen by forty-foot firing aisle, without warning, find themselves in the hold turned to hell by the escaping steam and water. There is no smooth floor to tread on, but instead, piles of coal and ashes and long, heavy firing-irons snare the feet.

The lights go out. Boiling water burns their feet and steam cooks their bodies. They cannot see, they cannot hear, and to rush too carelessly for the small doorway is to trip and fall into the scalding pool.

If steamships could not be run and commerce carried on without this kind of a sacrifice there would be nothing to do but to charge up so many more victims to the inevitable struggle, and let those who were sufficiently removed from the desolated homes and the wrenched heart strings forget it.

But the exigencies of marine engineering do not demand such a toll of human life. At some cost which "the traffic will bear" at some "inconvenience," less in the aggregate than that sustained by the victims and their dependents, conditions in the stokehole can be made such that a man need not commend his soul to God every time he goes on watch.

What is the reason that each boiler cannot be provided with inwardly or vertically opening furnace and ashpit doors and each combustion chamber have an opening into a substantial duct leading to the atmosphere above the water line? A damper made to stay shut normally by its own weight and the pressure difference between the sides, if placed in the duct at the boiler, would discharge most of the steam to the atmosphere in case of failure instead of blowing fire and steam into the boiler room. Sufficiently heavy plate used in the construction of the flue would provide a good outlet for steam, particularly if the front tube sheet should let go. The sketch on the opposite page shows diagrammatically the suggested plan. The arrangement, it seems, is applicable to most, if not all, boilers of this generally used type.

The "Jefferson," like nearly all vessels, was not provided with automatic nonreturn valves. True, due to the location of the boiler—near the only doorway exit—a few men might have been fatally scalded, even though such valves were provided, but in this case seven-eighths of the steam that filled the boiler and engine rooms never would have escaped if nonreturn valves had been used. That these valves are not more widely employed in marine practice is peculiar. They are generally reliable, and it is but rarely that one fails to operate when properly installed and maintained. Some modern vessels having water-tube boilers do use nonreturn valves, but one seldom finds them, and further, one cannot discover a good reason why they should not be used.

There is evidence that low water was the cause of the accident aboard the "Jefferson." The crown-sheet was sagged and the upper right-hand portion of the tube sheet was blown away from twenty-four tubes. The sheet was not badly burned, however, as the projected area was pushed back with a jack and new tubes were put in. The ends of the stay tubes were in good condition, the one from which the sheet blew entirely away was not distorted, and the hole in the sheet was perfect, except that it was enlarged just enough to allow the pressure—190 pounds, normally—to force it over the beaded tube end.

The ashes were being taken out at the time of the accident, and, on this ship, the pressure usually dropped thirty pounds when this work was being done.

Economy or Purchased Current?

On other pages of this issue an interesting estimate is made of the saving that would be effected if a large department store made its own current for power and lighting instead of buying it from a central station. The method of comparison is unusual, and perhaps some of our readers may not agree with the results obtained.

A discussion on the points of difference would be instructive and we will be glad to publish any legitimate comment from the central station, from Marshall Field's, which is the store in question, or from any of our readers who may have some knowledge of the plant. The question is too important to pass without comment. This particular store has been used time and again as an illustration of the efficiency of central-station service. If the service is saving the plant money, it would be interesting to know the amount, and at what rate the current is bought.

With the operating conditions stated in the article and the rate of 1.54 cents per kilowatt-hour, below which the central station cannot go without making itself liable for discrimination, it is a foregone conclusion that an uptodate generating plant would pay big returns. The boiler capacity already installed would be sufficient for the new conditions; the exhaust steam from the electrical load would supply the heating except for the few cold days in the winter when the temperature hovers around zero, and in average winter weather there should be exhaust steam to spare for the refrigerating plant and for the restaurant. The two services last mentioned would take a considerable portion of the exhaust steam during the summer months, so that a comparatively small amount would be wasted to atmosphere.

Conditions more favorable to an isolated plant do not often exist. Ordinarily, an isolated plant in which all the

exhaust steam is used for heating will produce results which the central station cannot meet. With a refrigerating load in summer and a restaurant using some of the exhaust steam, the conditions are still better. With its low-load factor and high fixed charges, the central station cannot lower the annual cost for the different services except at a heavy loss. At a rate of 1.54 cents per kilowatt-hour, it is certain that an isolated plant would effect a large saving and it would not be surprising if the annual gain reached the forty thousand dollars estimated in the article.

In the present case the coal can be received and the ashes removed through Chicago's underground freight tunnel, so that the argument based on dirt and annoyance usually advanced is void, and, for that matter, the plant is receiving nearly as much coal now as it would require with generating units in operation. The smoke nuisance should be no greater. It is indeed difficult to imagine any economic reason why the store should buy its current, but if there is an advantage, now is the time to give it publicity. It is hardly fair to continue using this store as an example favoring purchased current without stating the probable loss it is sustaining by not generating its own current. While engineers are not so easily deceived, building owners unfamiliar with technical matters might readily be influenced by the mere fact that a store of such magnitude was buying current. If they knew that this same store, possibly for personal reasons, such as are given in the article, was sacrificing every year a possible saving almost large enough to install an uptodate generating plant, they would think twice before following its example, if economy was preferred to central-station service.

An unbiased engineering analysis will surely point toward the isolated plant, and when the decision is made on this basis, there will be fewer buildings in Chicago and elsewhere in which the lighting and heating will be separated and the former bought at a considerable disadvantage.

End of a Culpable Practice in Sight

It seems to have become the accepted practice for New York City to install generating plants in its public buildings, then shut them down and purchase electricity. Notable instances are the City Prison (Tombs), the Williamsburg Bridge, Police Headquarters and the Raymond Street Jail, which has just been started again (see page 739). In the two latter instances, the generating plants had never been put in service, after their acceptance trials, yet the full operating force was retained in each case. The Williamsburg Bridge plant was taken out after having run for a short time.

If the load conditions in any of these cases were such as to make a generating plant unprofitable, one should never have been installed. Somebody blundered! Having installed a plant, however, with the investment and depreciation charges going on, as well as the labor, it is hard to conceive of conditions so bad as to render purchased current, at five or six cents per kilowatt-hour, cheaper than the cost of the additional steam and supplies for the generating units.

On the other hand, there are instances where the conditions are ideal for a generating plant and none has been installed. In this connection may be mentioned Bellevue Hospital (see POWER, Jan. 20, 1914) which has a large heating plant, ventilating system and refrigerating outfit. Here there is a large demand for exhaust steam during the entire year, and the electrical load averages over 85,000 kilowatt-hours per month, yet there are no engines and generating units.

Such a state of affairs can be attributable only to gross incompetency or willful intent to defraud the city. We believe it to be the latter. While each commissioner is responsible for the plants in his own department, we understand that practically all these plants were shut down upon the recommendation of the Department of Water Supply, Gas and Electricity, whose close affiliation with the New York Edison Company is a matter of common knowledge. Perhaps the responsibilty does not stop there; it may extend "higher up."

This connivance between the New York Edison Company, on the one hand and certain city officials or "near officials" on the other has probably cost the city a sum running into five ciphers. Fortunately the end seems to be in sight. The recent step taken at the Raymond Street Jail is but an opening wedge; as soon as the necessary repairs have been made, the Tombs plant will follow, and it is to be hoped that Commissioner Woods will emulate the example set by Commissioner Davis and order the plant at Police Headquarters started.

A Lesson from Recent Explosions

By a peculiar coincidence, there are described in this and last week's issues of POWER, two boiler explosions from similar causes at points remote from each other and of boilers of entirely different types. In each case the cause is attributed to a flaw or crack in the sheet and each flaw was so situated that it could not have been seen after the boiler was built.

In one instance it appears to have been a flaw in the original sheet, and not caused by rolling to shape in the boiler shop; by chance the sheet was located above the fire. The failure did not occur at a seam. In the other case it appears to be a combination of a brittle sheet and a severe forming strain. The failure occurred at the seam and the flaw was concealed by the strap.

The moral seems to be plain: More thorough inspection of plates during their manufacture.

An evidence of the growing tendency to put the rights of man ahead of the rights of property is seen in the following utterance of Gifford Pinchot in his campaign as a candidate for the Washington Party nomination for United States senator from Pennsylvania:

If elected I will work for a law giving to a national commission the power to limit the wholesale price charged by the anthracite monopoly or its agents in interstate commerce. The price fixed should consist of a reasonable price for coal at the mine, sufficient to provide good wages for the miners, and a reasonable charge for transportation and handling. A reasonable profit should be included. The saving to the public should be applied in part to greater safety for miners, and in part to lowering the cost of living by reducing the price of coal. The monopoly in anthracite coal, which is a necessity of modern life, should be subject to the obligations of public service. This monopoly charges high prices because it has the power. That power must be destroyed.

Correspondence

Holman's New Blowing Engine

Some statements made about a new blowing engine in the Mar. 3 issue call for a few remarks: The combination of a rotary and a gridiron valve is not new. It was patented July 16, 1901, by Charles A. Bennett of Dover, N. J. The drawings attached to patent specifications No. 678,534 show almost the same identical arrangement as Holman's, as may be seen from Fig. 1, herewith, showing two views copied from the specification drawings.

Bennett's valves have been in use for a number of years on air compressors and blowing engines built by

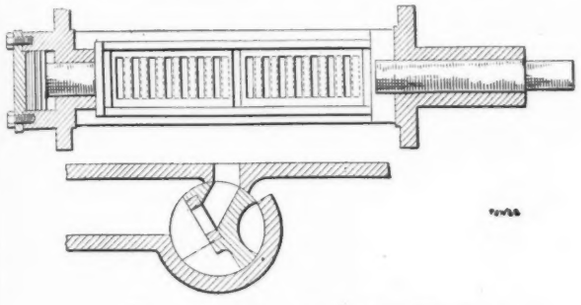


FIG. 1. BENNETT'S AIR VALVE

a Cincinnati concern. The only difference between the two designs seems to be that the gridiron valve in Bennett's device is actuated by air pressure, while Holman's valve is moved mechanically by a cam bar which resembles the cam motion that has been used for the last 15 years by the Southwark Foundry & Machine Co. to move the gridiron valves on its blowing engines. Holman's mechanism is rather complicated.

The statement that "the use of the flat gridiron and Corliss valves for compressors and blowing engines has not been attended with the best results on account of the difficulty in lubricating the inlet valves," cannot go unchallenged. There has never been the least difficulty in lubricating these valves; in fact, they seem to be more easily lubricated than any other part of the mechanism.

A few figures will show what the inlet valves will look like if the inlet area is to be made 25 per cent. of the cylinder area. Take, for instance, a 60-in. diameter blowing tub, the area of which is 2827 sq.in.; 25 per cent. of this is 707 sq.in., which divided by 2 gives 353.5 sq.in. inlet area for each valve. Assume that the ports are 60 in. long—which, of course, is hardly possible, since they cannot be located on the center line. Even so, the width of the ports would have to be about 6 in., requiring valves of at least 12-in. diameter. Imagine four such valves for an engine with a piston speed of 900 ft. per min. to move, say, $2 \times 90 = 180$ times a minute through an arc of about 80 deg. Consider the inertia of the moving parts. A valve-gear like that and running at the speed assumed would go to pieces in a short time. If the engine had a stroke of 54 in. instead of 60 in., as in the foregoing calculation, the number of revolutions would be increased from 90 to 100, and matters would become still worse.

Piston speeds of 800 or 1000 ft. per min. are not desirable for Corliss engines, gas engines, blowing engines, etc., if they are installed with a view to lasting and giving good service. Blast-furnace blowing engines, as a rule, are run night and day for long periods with a few stops a day for casting. It is, therefore, not advisable to run them at such excessively high speeds. It is doubtful if it pays to run reciprocating engines over 700 ft. per min., which should also be the limit for blowing engines. The first cost of an outfit running at higher speed is less than one running at moderate speed, but first cost should not be the only consideration, for wear and tear and efficiency must be taken into account.

Another erroneous idea in the article is that large Corliss valves can be made interchangeable and that one spare valve will be sufficient for an engine. Any shopman knows that it is impracticable, if not impossible, to bore four portholes of 10- or 12-in. diameter, 5 or 6 ft. long, exactly alike. Each valve must be fitted to its own porthole to be tight; besides, the wear of two valves or two portholes is never the same, so it would be of little use to keep one finished valve on hand.

American engineers have struggled for a number of years with indifferent success to design mechanically operated valve-gears for blowing tubs driven by gas and steam engines at high piston speeds. The blowing cylinder, in which the tub itself forms the inlet valve, as shown in Fig. 2, is an example. In this design the air is drawn in through openings in the cylinder shell. By this means an inlet area of 25 per cent. and over of the piston area can be attained, and the clearance in the inlet is reduced to zero. The objection to this valve-gear is the

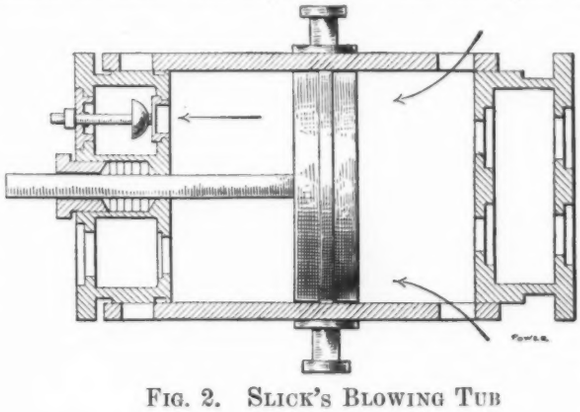


FIG. 2. SLICK'S BLOWING TUB

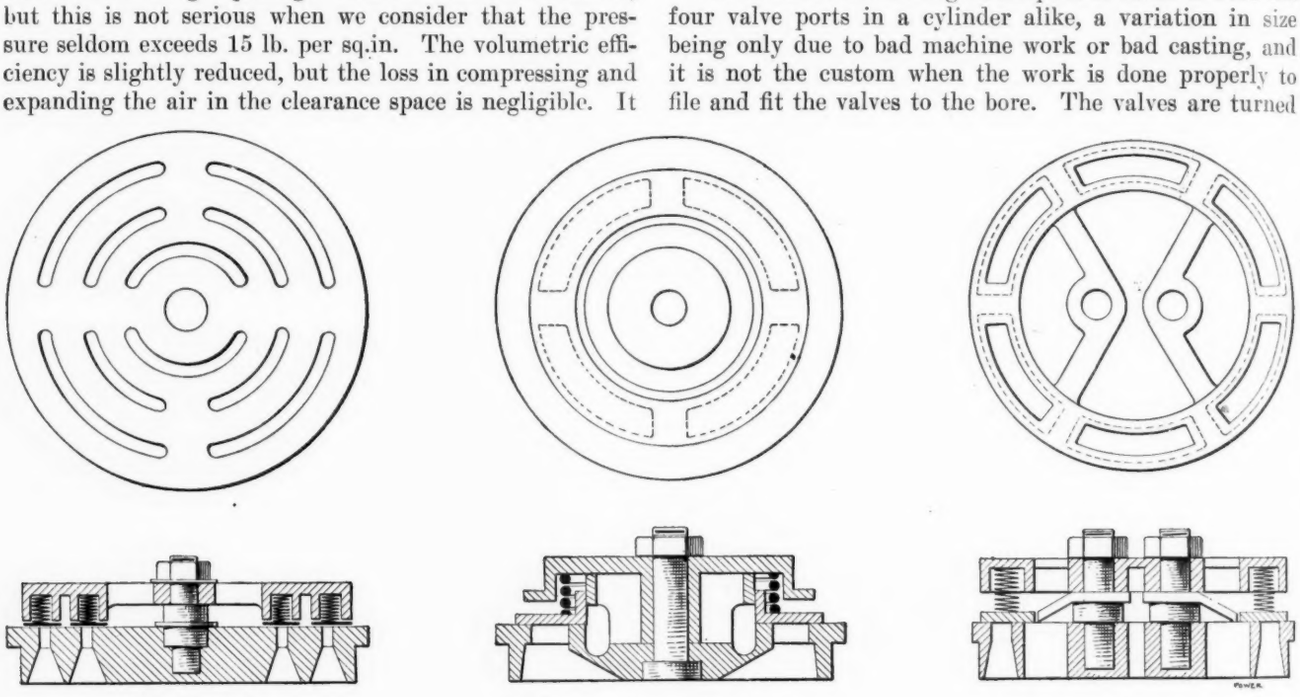
inertia of the blowing tub and the power absorbed in moving it back and forth. Take, for example, a 60-in. blowing cylinder with a stroke of 54 in. for 80 r.p.m. If the cylinder weighs 7000 lb. and the travel is 10 in., including the friction of the packing rings and the driving mechanism, it would probably require from 25 to 30 indicated horsepower to operate the valve-gear, or from 4 to 5 per cent. of the total.

European engineers who have been confronted with the problem of adapting blowing engines to high piston speeds for a longer time, due to the early development of gas-engine-driven units, have almost entirely discarded mechanically operated valves for plate valves, as shown in Fig. 3, where are shown designs by Hoerbiger, Ehrhardt & Sehmer, and by Borsig.

Valves of this kind do not require extra eccentrics and ponderous driving mechanism. They improve the mechanical efficiency of the engine and reduce the wear and tear and the cost of repairs. A blowing tub as usually made in Europe is shown in Fig. 4. The valves are placed opposite one another in the heads, concentric to the bore of the cylinder, giving a large area for the inlet and discharge openings. The clearance is increased, but this is not serious when we consider that the pressure seldom exceeds 15 lb. per sq.in. The volumetric efficiency is slightly reduced, but the loss in compressing and expanding the air in the clearance space is negligible. It is a curious fact that this design is almost identical with the blowing tub which Edwin Reynolds built over 20 years ago for some plants in the Middle West.

H. Hamkens.

Newark, N. J.



Hoerbiger Ehrhardt and Sehmer Borsig

Fig. 3. Plan and Sectional Views of Different Types of Valves

---

It was not claimed in the article under discussion that the combination of a rotary and gridiron-iron valve working together was new, nor that moving the gridiron valve with a cam bar was new. The combination of gridiron and rotary valves is covered by both Bennett's and Holman's patents. The application and arrangement of the rotary-gridiron valve is described whereby very large inlet areas, ease in removal and renewal of parts, efficient lubrication and positive mechanical movement of all the valves are obtained is, as far as I know, decidedly new.

In regard to Mr. Hamkens' statement that it is not difficult to properly lubricate inlet valves of the Corliss and gridiron type, I can only repeat that the difficulty does exist, and it is a very real one, as he may readily ascertain by investigating plants where large machines of such a type are operating. In the machine described the inlet valves are as easily lubricated as the main crosshead.

In order to relieve Mr. Hamkens' fear of Corliss valves, 12 in. in diameter and their inertia, I would refer him to any of the large engines in rolling mills and power plants where it is common to see Corliss exhaust valves much larger than 12 in. operating without any signs of distress after years of continuous and severe service. By large engines I mean 4000 hp. and over, operating at 80-85 r.p.m., a not unusual condition.

Piston speeds do not determine the life of the valve-gear; in fact, there is no relation between the two, and in modern plants a limit of 700 ft. per min. piston speed is not usual.

In first-class Corliss engine shops it is usual to bore the four valve ports in a cylinder alike, a variation in size being only due to bad machine work or bad casting, and it is not the custom when the work is done properly to file and fit the valves to the bore. The valves are turned and sometimes ground a few thousandths smaller than the bore and that is all.

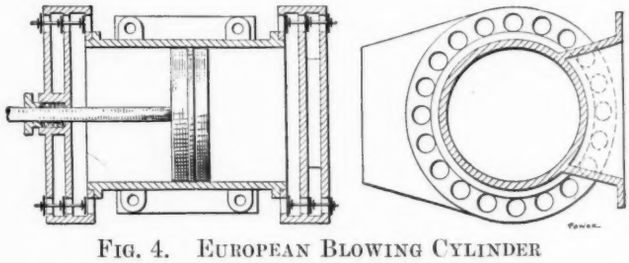


Fig. 4. European Blowing Cylinder

Of course, if the port gets cut and it is necessary to rebore it, a reserve valve will not fit, but that condition is by no means usual. In most cases an extra valve will fit any of the ports in a cylinder. In the machine described, all the valves are moved positively, the actuating piston only determining the position of the fulcrum block in its curved path, so that the outlet valve may open at the proper time.

If the actuating piston should fail to work, the machine would still pump its full capacity of air, the inlet

valves opening and closing and the outlet valve closing at the proper time, while the opening of the outlet valve only would be deranged, which would not seriously affect the operation of the machine. With this type of machine it is impossible for the blast to blow back through the machine, due to breakage or derangement of the gear, something which cannot be said of plate valves. Indicator diagrams taken from such a machine show a most satisfactory distribution of air.

R. C. Holman.

Lynn, Mass.

Engineer's License Laws

Mr. Behen's letter, in the Apr. 21 issue, helped to again arouse my indignation toward the careless manner in which our lawmakers have spent their time at various state capitols revising, remodeling and building laws of little or no consequence to most people. Mr. Behen thinks that West Virginia should have strict license laws. Well, this is not the only state; there are plenty of others.

While I was engaged in erecting stokers at a coal mine in Pennsylvania a few years ago, they had a small firebox boiler for temporary use which they had loaned to a farmer earlier in the fall. The farmer came back and informed the master mechanic that he had fired the boiler as hard as he could for two days and could not get over 7 lb. of steam. The gage had been sprung and the only water in the boiler was in the water leg. The boiler was not so valuable after that.

In a sawmill in Michigan that was being rebuilt and prepared for a run, was a small duplex pump that had had the exhausts plugged upon being shut down after the previous run. The engineer and the master millwright were quoted as saying that as it was a cold-water pump it needed no exhaust; still, they were at a loss to know why it could make but a few strokes and then would come to a standstill.

After taking out one of the plugs as advised by one of the millwrights, the engineer smiled like a boy with a new toy to see how nicely the pump would run. The main point, however, is that we need some sort of regulations governing the operation of power plants. At the present time, I believe the federal government issues licenses after proper examinations to engineers on the lakes and the ocean, but in most of our cities, as far as the law is concerned, any one who knows the throttle from the blowoff can jeopardize the the lives of many persons in office buildings and factories.

I think it is about time "Uncle Sam" exercised some authority in compelling the various states to frame a system of "Safety First" laws for power plants, and letting uniform divorce laws lay over on the table for another week or two.

R. E. Keech.

Elkins, W. Va.

It may be consoling to Walter B. Behen to know that there are underpaid engineers in places where there are license laws. Ontario has a government license law but it is easy to find engineers working 12-hr. shifts for from $12 to $15 per week. In lower Canada a lot of them work for even less. Toronto City pays laborers, including street sweepers, $15 per week. There are hundreds of firemen and assistant engineers in Toronto and other places receiving from $25 to $50 per month, including board. The last item would be worth about $12 to a single man; to a married man, next to nothing. There are many chief engineers in Ontario, good men, receiving from $75 per month up, but it is only in important plants.

A license law is good for the employer, as it makes better engineers, but it does not mean more pay for the engineer in all cases. It is a fact that the pay for engineers in small or average plants has not increased for many years, as it has with almost, if not all, other mechanical workmen.

Twenty years ago and more the technical press had practically the same editorial matter in connection with this complaint from engineers as they have now. We appear to be afraid to demand our rights.

James Ellethorn.

Toronto, Ont., Canada.

Care of Boiler during Shut-down

I agree with F. E. Worley, in the Apr. 21 issue, page 565, that a boiler should be cleaned outside and inside, but if left emptied, it should be carefully dried, and not left to be air dried. It is difficult, however, to understand how so much rust could collect on the tubes if a boiler is filled with water and the temperature of the water is raised to that of the air at the time of filling. No rust should collect, because the water will adapt itself to the outside temperature or weather changes.

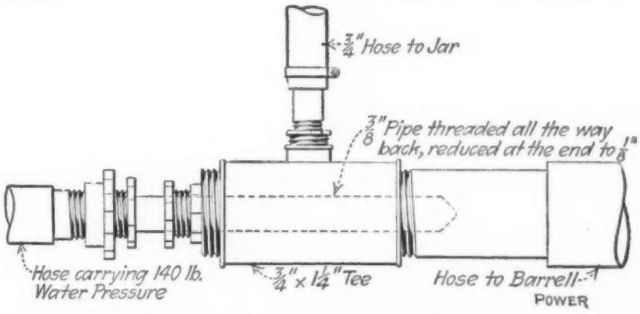
With a large number of return-tubular boilers used during the winter months and left full of water during the summer, I have never seen a sign of rust on any of the tubes. Surely there is no country where the atmospheric changes are greater than here.

Morris E. James.

Toronto, Ont., Canada.

Cleaning Storage-Battery Cells

The usual method of getting rid of the sediment which accumulates in the bottom of storage-battery cells is to take the plates out of the jars before cleaning them. When the plates are removed from the jars the old separators


3/4" Hose to Jar
3/8" Pipe threaded all the way back, reduced at the end to 1/8"
Hose carrying 140 lb. Water Pressure
3/4" x 1/4" Tee
Hose to Barrell
POWER

Ejector for Siphoning Contents of Jars

become useless and have to be replaced with new ones. This all takes considerable time, and when the battery is of 50 amperes or more capacity, the job of cleaning is not the most desirable, to say the least.

Recently it became necessary to remove the sediment from the jars of a 132-cell, 50-ampere battery in a plant

with which the writer is familiar. A method somewhat resembling the one described by Mr. Dawson in the Dec. 9, 1913, issue of POWER, was used. Instead of removing the plates from the jar, however, they were left in place while the cleaning was going on. A home-made injector was made up of a ¾x1¼-in. tee and some fittings (see sketch), and was made portable so that it could be carried between the rows of cells. In this case water at 140 lb. was used to operate the siphon, although the arrangement will work with steam or compressed air. There is space enough between the jar and the plates to admit the ¾-in. hose. The acid was first siphoned out and was used again for the same purpose. After all the sediment was removed and the jar flushed until clean, the acid was replaced. Except in isolated cases, it was not necessary to replace the old separators with new ones. This method of cleaning saved time and the cost of nearly an entire set of new separators, besides eliminating much heavy lifting.

H. G. GIBSON.

Washington, D. C.

Repair to an Armature

A 1500-kw., 600-volt, direct-current generator, operating in parallel with two similar machines and supplying power to a street-railway system, suffered a severe burnout in its armature, several coils being destroyed.

When the armature was examined, it was found that one of the coils had grounded to the core. As the negative side of the system is grounded, this resulted in a large current flow, a hole about 2 in. in diameter and 2 in. deep being burnt into the armature core. The repair was made as follows:

The armature being cleared of the burned-out coils, the hole was chiseled out until it was 3 in. square and 2¼ in. deep. This was rendered easier as the hole was burned close to one edge of the core. Care was taken to carefully file off all burrs resulting from the chiseling. A laminated block was next made up to fit exactly the hole, the laminations being shellacked before being riveted together. The laminated block was then placed in a milling machine and slots cut in it to correspond with the slots in the core. When a good fit was secured, the core was drilled and tapped and the block held in place by two countersunk screws. Care was necessary in drilling and tapping the core.

After the coils were replaced, the machine was started and has since run almost continuously without the slightest evidence of local heating.

EDWIN L. HINCHLIFF.

Duluth, Minn.

Replacing a Wristpin Brass

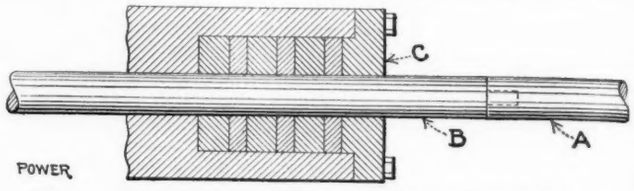
A wristpin brass on a 100-hp. tandem gas engine ran hot and had to be scraped and refitted. This in itself was not much of a job, but, on account of the construction of the engine, getting the brass out and in again was quite a task and as the engine could not be spared during the day, the work had to be done at night.

The engine is a two-cylinder, single-acting tandem machine with both pistons on the same rod, and a stuffing-box in the front head for the piston rod to pass through. In order to get the wristpin and brass out, the rear cylinder head had to be taken off, the rear piston taken off the rod, the connecting-rod disconnected from the crank-pin brass and the front piston pushed ahead until the pin cleared the forward end of the front cylinder. The pin could then be removed and the brass and connecting-rod taken out intact.

When the piston was pulled forward enough to do this, the back end of the piston rod would be through the stuffing-box and the garter springs on the metallic packing would close up the packing until it would be impossible to get the rod entered again.

It was the usual custom to take out the packing cage, but this time I set out to devise some way to shorten the work. The sketch shows how it was accomplished; *a* is a piece of shafting of the same diameter as the piston rod, *B* is the rod and *C* the packing cage. The shaft was bored out in a lathe to fit over the threaded part of the piston rod and fit up against the shoulder as shown.

When the piston rod passed through the packing, the



MEANS FOR REMOVING PISTON ROD WITHOUT GLAND PACKING COLLAPSING

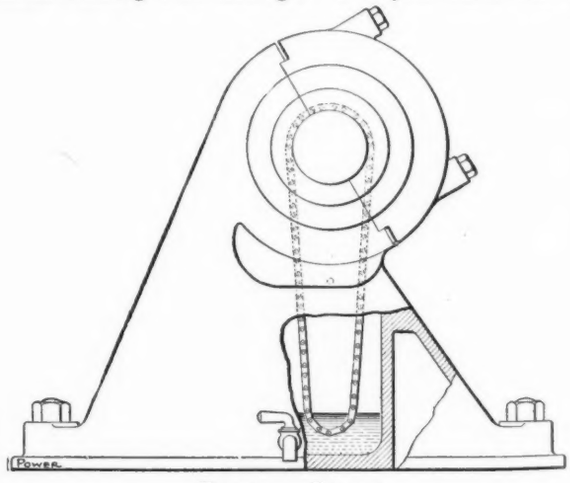
shaft entered and held the rings expanded until the rod was ready to go back, when the operation was reversed. This saved taking the packing cage out and replacing it, which meant at least an hour's work, and most engineers know how to appreciate an hour when they have worked from 6:30 a.m. until 10:30 p.m.

EARL PAGETT.

Coffeyville, Kan.

Bicycle Chain as Oil Carrier

The original brass-chain oil conveyor on the outboard pedestal bearing wore through. A bicycle chain was substituted and it proved more satisfactory by reason of its greater weight.



BICYCLE CHAIN

EDWARD T. BINNS.

Philadelphia, Penn.

Building a Smokeless Furnace

In the issue of April 21, under the above heading, is an article by Mr. Shoemaker, which all are invited to discuss.

To burn anthracite coal in a furnace designed for bituminous coal is as bad as burning bituminous in a furnace designed for anthracite, therefore the economy claimed by Mr. Shoemaker is not only possible but natural. There is no more reason to expect good economy from the use of one furnace for all kinds of fuel than from the use of one pair of shoes for a whole family consisting of father, mother and a two-year-old boy.

Mr. Shoemaker says: "I find it much better to set the boiler at least 36 in. above the grates. I do not carry the bridge-wall more than 14 in. above the grate surface and extend it straight across the furnace. The object is to keep the shell away from the fuel so that when using long-flame bituminous coal, complete combustion will take place before the flame strikes the shell." Does this accomplish the object?

From my observation of furnaces in which boilers are set from 24 to 52 in. from the grate to the shell, the flames always hug the shell of the boiler during the distillation period of the fuel.

Further on, we have the following: "One method I have used to prevent smoke is to run three or more small air ducts behind the fire-brick lining of the inside wall of the furnace with openings so that the air can enter these ducts just beneath the grate surface, and open the outlet of the air duct in the side walls to a level with the lowest portion of the boiler shell." He then says: "The principle of this method is to have a slight blanket of highly heated air in contact with the boiler shell above the fire and bridge-wall and keep the flame from striking the shell." The principal claims for the method are chimercial and the virtues are imaginary, for an impossibility is claimed.

To accomplish the protection of the boiler from the flames or the flames from the boiler "with a slight blanket of highly heated air," the air must cover the shell of the boiler. To do this it must travel from the side wall to the shell at right angles to the force of the draft which made possible its entrance into the furnace, and then at 180 degrees, 90 degrees toward the fire door and 90 toward the bridge-wall. If there is no other force to project the air and neutralize the effect of the draft, the air so admitted will be controlled by the force of the draft, and as soon as it enters the furnace it will be pulled toward the flues and its direction will be but coincident with the pull of the draft. The benefit of the air admitted into the furnace in the manner indicated will be limited by the amount of unburned gases passing along the side wall with which it may mix.

I expect that Mr. Shoemaker will ascertain the facts for the benefit of POWER readers; they can be easily ascertained. First, take the idle boiler, place ignited oiled waste at the intake in the ashpit, close the fire-doors and open the damper. The direction of the air entering into the furnace will be indicated by the smoke taken with it, and a person on the grate with an extension light can easily see where it goes and determine whether the air forms a blanket about the boiler or makes a bee line for the stack.

Then seal the intake into the air duct, other conditions being unchanged, and note the effect on the smoke and the economy.

H. MISOSTOW.

Chicago, Ill.

Spherical Boiler Heads

In POWER for Jan. 13, T. T. Parker rightly points out that it is incorrect to calculate the strength of spherical boiler heads by treating them as spheres. The rule he suggests, however, perpetuates this error, although by using a larger factor he minimizes the risk of arriving at dangerously light plate thicknesses.

As a matter of fact, any rule of the form

$$t = \frac{R \times factor \times P}{T.S.}$$

assumes that the head is stressed as a sphere and is in consequence essentially incorrect. The stress in a sphere

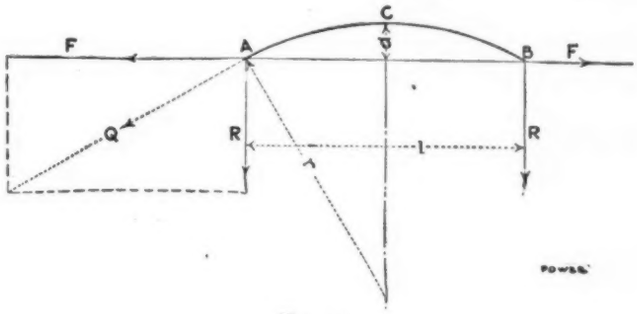


FIG. 1.

is a simple tensile stress without any bending whatever, but in the case of most spherical boiler heads there is a considerable bending stress of indeterminate amount.

The fact is that the manner in which the head is stressed is determined, not by its shape, but by the stiffness of the shell into which it is riveted. The radius of curvature of the spherical portion has not necessarily any direct relation to the stress in it.

It is a somewhat difficult matter to grasp this problem, but by considering a cambered beam subject to a uniform radial pressure, the idea becomes clearer. The stresses in a cambered beam can be worked out quite closely and the analogy between it and a spherical head is sufficiently good to enable one to form a reasonably correct view of the nature of the stresses.

In Fig. 1, ACB is a cambered beam of radius r, the versin being d, and the chord $AB = l$. The beam is subjected to a uniform radial load of p pounds per square inch, and is supported at the ends, each reaction being equal to R.

The bending moments acting at the center of the beam are:

Bending moment due to reaction =

$$R \times \frac{l}{2} = p\frac{l^2}{4} \left(since\ R = p\frac{l}{2}\right)$$

This acts downward and will be designated as +.

Bending moment due to the vertical component of the radial force =

$$-p\frac{l}{2} \times \frac{l}{4} = -p\frac{l^2}{8}$$

Bending moment due to the horizontal component of the radial force =

$$-p \times d \times \frac{d}{2} = -p \frac{d^2}{2}$$

The resultant bending moment is, therefore,

$$p \frac{l^2}{8} - p \frac{d^2}{2} \qquad (1)$$

Now introduce at A and B horizontal forces F, pulling on the ends of the beam. These forces produce a bending

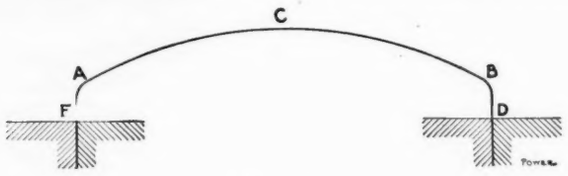


FIG. 2.

moment which is a maximum at the center of the beam and $= F \times d$. This bending moment acts in a sense contrary to that produced by the reaction and, therefore, may be considered negative. The resultant bending moment now becomes

$$p \frac{l^2}{8} - p \frac{d^2}{2} - Fd \qquad (2)$$

Combine the forces F and R into a single force Q, and it may be shown that the sum of the quantities in (2) is zero, when Q is tangential to the beam at the ends, its value being $p \times r$, which is recognized as being the stress in a cylinder under fluid pressure.

If, therefore, instead of supporting the beam at the ends it is attached by pin joints to supports capable of withstanding, without deflection, a pull equal to $p \times r$, the bending moment is eliminated and the beam is stressed as a cylinder. On the other hand, if the supports are not stiff enough to withstand a pull of $p \times r$ without deflection the beam is subject to a bending moment. It appears, therefore, that the nature of the stress in the beam is determined, not by its shape, but by the manner in which it is attached to surrounding parts.

To extend the case now to a beam of the shape shown in Fig. 2, consider this as being made up of a circular arc ACB jointed by pin joints at A and B to abutments EA and DB. From the preceding arguments it is evident that the part ACB can only be considered as under no bending moment on the assumption that the end parts EA and DB are able to withstand without deflection a horizontal pull equal to F, where

$$F = \sqrt{Q^2 - R^2}$$

$$R = \frac{pl}{2}$$

and

$$Q = p \times r$$

Suppose, now, the horizontal force actually applied at A is less than

$$\sqrt{Q^2 - R^2}$$

Let this force be represented by Aw (Fig. 3), where F is represented by Az. The effect will be to leave a bending moment on the beam, which will be a maximum at C, where it will equal

$$(Az - Aw) \times d$$

Consider now the case of a dished end under fluid pressure. Using the notation of Fig. 1,

$$R = \frac{pl}{2}$$

$$Q = p\ r$$

and

$$F = \sqrt{Q^2 - R^2} = \sqrt{p^2 r^2 - \frac{p^2 l^2}{4}} = p \sqrt{r^2 - \frac{l^2}{4}} \qquad (3)$$

It will be seen that when $r = \frac{l}{2}$; that is, when the end is hemispherical $F = 0$ and when $r = l$, F = 0.866 $p \times r$. The thickness has not been introduced so far and the forces are per inch of width.

Actually in a dished end there is no internal force applied equivalent to F and, as in the case of the beam, a force is only introduced by the resistance to deflection. When dished ends have been tested and the deflection gaged it has been found that the crown (C) moves out and those parts of the circumference (A and B) come in showing that the annular ring of metal around the circumference is in compression. The resistance to compression of the outer ring, therefore, provides the force F, and unless this resistance is sufficiently great, the cambered part cannot be correctly treated as spherical, as regards the way in which it is stressed.

If the cambered part is to be treated as being stressed in tension, that is, as a sphere, it follows that the resistance to compression of an annular ring at the circumference equals a radial force

$$F = p \sqrt{r^2 - \frac{l^2}{4}}$$

In order to get a rough idea of the possible intensity of compressive stress which would be induced by a radial force equal to F, we will take one of the ends tested by Bach in his classical experiments. In this case r was

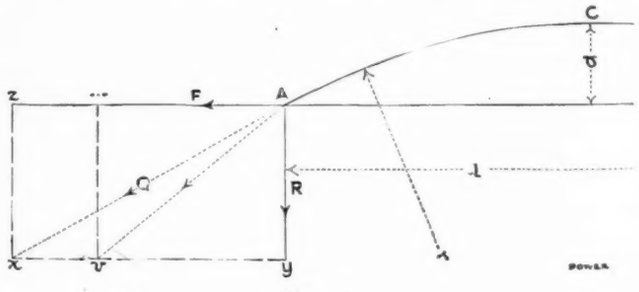


FIG. 3.

40.5 in.; t, 0.39 in.; l, 24 in., and p, 205.8 lb. per sq.in.

Therefore, $F = p \sqrt{r^2 - \frac{l^2}{4}} = 7950\ lb.$

We are quite in the dark as to the depth of the circumferential ring, which may be regarded as being in compression, but suppose it be assumed to be 3 in. deep, and let f be the compressive stress on this ring 3 in. deep by 0.39 in. thick, due to a radial force of 7950 lb. per sq.in.; then,

$$f = \frac{7950 \times 24}{2 \times 3 \times 0.39} = 81{,}500\ lb.$$

It is improbable that such stresses actually occur and it is more reasonable to suppose that the case is analo-

gous to that of the beam, first considered, and that the cambered part offers resistance to buckling and is not by any means stressed as a sphere.

The right way to regard a cambered boiler end would appear to be to treat it in the same way as a flat plate which would then become the limiting case where the radius is large. The formula for the safe pressure of cambered ends would then contain the area of the end and the depth of the versine as factors together with a coefficient and the square of the thickness, thus

$$p = \frac{C \times t^2}{S}$$

where

p = Safe pressure in pounds per square inch;
t = Thickness;
S = Area of end;
C = Coefficient depending on the ratio of versine to radius of camber.

A. C. Wilson.

Manchester, England.

Tests of a Simple Noncondensing Lentz Engine

In the issue of Dec. 2, 1913, was given an account of tests carried out by Prof. J. A. Moyer on a 19x21-in. simple noncondensing Lentz engine built by the Erie City Iron Works. The economies and heat consumption obtained by this engine were so remarkable that a discussion of these tests is very appropriate.

The writer, having introduced the Lentz engine into this country and having designed the engine in question, can approach this subject without any prejudice whatever, although occupied at present in competitive lines.

In Table 1, the figures as published are recapitulated, and in the last column are added the Rankine efficiencies, based on adiabatic expansion to wet steam at the terminal pressure given.

TABLE 1. RESULTS OF TESTS ON A SIMPLE LENTZ ENGINE

No. of Test	Duration of Test, Hr.	Speed, R.p.m.	Mean Effective Press., Lb. per Sq.In.** H.E.	C.E.	I.hp.	Steam per I.hp. per Hr., Lb.	Absolute Steam Pres., Lb. per Sq.In	Back Press., In. of Mercury	Superheat, Deg. F.	Rankine Eff., %
1	4	208	46.35	45.92	282.1	15.24	170.3	0.34	141.5	85.8
2	3	208	24.83	28.40	162.7	17.25	170.1	0.00	98.3	77.8
3	3½	211	36.19	37.08	227.6	15.78	171.9	0.00	139.4	82.9
4	1†	207	53.40	52.22	322.5	15.48	171.7	0.10	159.7	82.7

**Calibrated scales of springs of indicators are respectively, 78.9 and 79.3 lb. per sq.in.
†Generator would not carry load for a longer time on account of heating.

While tests Nos. 1, 3 and 4 correspond closely as to the Rankine efficiency, decreasing with the decreasing number of expansions, test No. 2 seems to differ very much. There is no apparent reason why the efficiency in the latter case should be about 8 per cent. less than that of test No. 1. On account of the lower superheat a difference of about 1 per cent. may be expected, all other conditions remaining the same, but the more complete expansion maintained during test No. 2 should tend to increase the efficiency.

It is impossible to form a logical explanation for this discrepancy, but the exhaust temperatures, Table 2, may supply a basis for approaching this problem.

TABLE 2.

No. of Test	Steam Consumption per I.hp.-hr., Lb.	Abs. Steam Pres., Lb.	Temp. of Exhaust, Deg. F.
1	15.24	170.3	220.3
2	17.25	170.1	212
3	15.78	171.9	223.6
4	15.48	171.7	235.3

From my own observations during the tests I can vouch that all readings were observed with the greatest care, and the instruments were carefully calibrated. However, the exhaust temperatures observed in tests Nos. 1, 3 and 4 (test No. 2 will not be discussed on account of the absence of a calorimeter reading) seem to indicate that an error has crept in which apparently could not have been detected by those conducting the test.

In my opinion it is not probable that a mistake was made in determining the steam consumption as the observations made at certain intervals during the tests checked up very closely and I am inclined to consider the exhaust temperatures as correct. I have, therefore, come to the conclusion that the superheat maintained was considerably higher than indicated by the calibrated thermometers.

With this assumption Table 3 was calculated, giving in column 5 the amount of superheat apparently carried in the steam chest, in column 4 the B.t.u. actually converted into work per pound of steam, and in column 6 the same, but for adiabatic expansion.

TABLE 3.

No. of Test	Steam Press. Abs., Lb.	Steam Cons. per I.hp.-Hr., Lb.	Temp. of Exhaust, Deg. F.	Work Done per Lb. of Steam, B.t.u.	Superheat, Deg. F.	Work Done per Lb. of Steam During Adiabatic Expansion, B.t.u.	Rankine Eff., Per Cent.
1	170.3	15.24	220.3	167	236	212	78.7
3	171.9	15.78	223.6	161	226	210	76.7
4	171.7	15.48	235.3	165	246	214	77.2

Take, for instance, test No. 1. We know the exhaust contains about 1154 B.t.u. per pound, also that during expansion 167 B.t.u. were converted into work per pound of steam. Hence the steam on entering the cylinder must have contained approximately 1321 B.t.u. per pound (neglecting radiation) and with a pressure of 170 lb. absolute a superheat of 236 deg. F.

If using the Mollier diagram instead, we locate the point where the curves of 15 lb. pressure and 8 deg. superheat intersect, then passing vertically upward a distance representing 167 B.t.u., following this abscissa until we intersect the curve of 170 lb. pressure, a superheat of about 236 deg. is indicated. The vertical distance from this point to the 15-lb. pressure line represents the work of 1 lb. of steam in B.t.u. during adiabatic expansion.

Naturally, the question arises whether or not it is possible that a much higher superheat than indicated by the thermometers was actually carried, a question which must be answered in the affirmative in view of the experiments carried out by Dr. Armand Duchesne, of the University of Liége. V. Dwelshauvers-Dery, late professor emeritus of the University of Liége, in discussing the investigations of Duchesne, writes:

"Two difficulties are to be found in the measurement of the temperature of superheated steam passing even slowly through a space, as a pipe. First, the temperature is not uniform throughout the mass as it would be with saturated steam, on account of the slow conductibility of the superheated fluid. An instrument is necessary which gives the average temperature, as the piston

of the indicator gives the average pressure, and instantaneously as does the indicator piston. In this connection it is safe to say that the mercury thermometer can give only the local temperature, and that tardily, especially if it is in a cup of oil. The hyper-thermometer of Duchesne with its numerous junctions disseminated through a large space and its excessively small mass sensible to heat, meets these conditions as far as is practically possible.

"The importance of the effect of these two factors will be appreciated when it is remembered that in some of the experiments the difference between the mercury thermometer in its oil bath and those of the more responsive and sensitive thermocouple amounted to more than 80 deg. C. (144 deg. F.)."

The investigations of Duchesne showed, furthermore, that with saturated steam a temperature for all purposes constant and uniform was obtained, no matter whether determined by the mercury thermometer or by the hyper-thermometer of Duchesne and that the error increased with the increasing superheat and decreased with increasing pressure.

The explanation given by Duchesne of the difference between the temperatures indicated by the hyper-thermometer and the mercury thermometer involves, according to Dwelshauvers-Dery, the hypothesis that in the body of the same mass of superheated steam are to be found contiguous layers or strata of steam of different temperatures. Hirn had already remarked this, and Duchesne has demonstrated it experimentally. He has shown even that there may exist strata of saturated steam. In brief, then, one first point is established that with superheated steam all observations of temperature may be false if not made with a thermometer practically without mass.

In adopting the views and experiments of Duchesne as being correct, one must come to the conclusion that in the tests of the Lentz engine the exhaust temperatures are approximately correct, while the corresponding temperatures taken in the steam chest are subject to the discrepancies due to the inadequate instruments used.

There are other reasons which convince me that my assumptions are correct. A test was carried out after completing the above tests to determine also the economy of the engine running with saturated steam and the following results were obtained:

TABLE 4.

Duration of Test, Hr.	Speed R.p.m.	Average I.hp.	Steam Consumption per I.hp. per Hr., Lb.	Abs. Steam Pres., Lb.	Moisture, Per Cent.
4	208.9	230	25.2	175.1	4.13

An allowance of 3 per cent. for each 1 per cent. of moisture can justly be given as condensation is increased by the presence of moisture. With this correction the consumption of perfectly dry steam would become 22 lb. per i.hp.-hr. with a Rankine efficiency of 65 per cent. This consumption is reduced by about 30 per cent., as shown in test No. 3, Table 1, due to the superheat, a saving which to all previous records of poppet-valve engines may well be expected with 250 deg. superheat but impossible with 140 deg. superheat. These records show that 250 deg. superheat will lower the steam consumption of a compound engine approximately 23 per cent. and that of a simple engine 28 per cent., figures which emphasize the correctness of my assumption that the superheat carried during the test was about 240 deg. F.

The following also seems to support my conclusions: A test was made by the R. W. Hunt Co., of Chicago, on a 15x21-in. simple noncondensing Lentz engine installed at the Throop St. plant of the Peoples Gas, Light & Coke Co., Chicago, Ill. In this case an economy of 18.6 lb. per i.hp.-hr. with 147.6 lb. gage pressure and 49.5 deg. F. superheat was obtained, giving a Rankine efficiency of 75.9 per cent.

The 17x21-in. simple noncondensing Lentz engine installed at the plant of the Randall-Faichney Co., of Jamaica Plains, Mass., showed a Rankine efficiency of 78.4 per cent. and a steam consumption of 17.2 lb. per i.hp.-hr. when operated with 140 lb. pressure and 150 deg. superheat.

The plain tube superheater used during the test conducted by Professor Moyer on the 19x21-in. Lentz engine was undoubtedly capable of producing the superheat assumed in Table 3. It was placed just behind the bridge-wall of a horizontal water-tube boiler of the Erie City type and sheet-iron baffle-plates were so arranged that the gases impinged directly on the superheater after having been in contact with the lower bank of tubes.

From my own observations in a previous test I noticed that the thermometer on the superheater outlet indicated 200 deg. F. superheat while that placed at the engine about 30 ft. away showed a superheat of about 90 deg., though the pipe line was well covered with nonconducting material. At that time I was unable to find a reason for this difference in readings.

In summarizing it has to be admitted that tests Nos. 1, 3 and 4 of Table 1 do not correspond with tests made on other engines of the same type and built by the same concern. Of particular interest is the Rankine efficiency of 65 per cent. of the 19x21-in. engine when working with dry-saturated steam as it is obviously impossible that this efficiency could be increased by 18 per cent. when operating with 140 deg. superheat while an increase of about 12 per cent., as given in Table 3, with 240 deg. of superheat can be expected with the cylinder design used. In this particular case the engine was not operated under the most favorable conditions as the cylinder was originally designed for a 21-in. bore and in decreasing the diameter to 19 in. the clearance volume was materially increased, making it about 12 per cent., also materially enlarging the clearance surface.

It is my opinion that even with the modified figures of Table 3 the results are remarkable though by no means world's records. It is my firm belief that better economies can be obtained in a poppet-valve engine where clearance in surface and volume is reduced to a minimum, with the emphasis on the former. The possibility of entirely machining the clearance surface would enhance the value of such design. The recent experiments carried out in Professor Bach's laboratory at the Technical College of Stuttgart prove again the importance of this much neglected arrangement.

In concluding I should recommend on account of the obvious difficulty in reading superheats correctly with the instruments ordinarily in use, that in such cases the exhaust temperatures be read and calorimeter readings be taken in order to arrive at more accurate results.

S. Rosenzweig,
Consulting Engineer, York Manufacturing Co.
York, Penn.

Inquiries of General Interest

Taper of Pipe Screws—What is the standard taper for screw-threaded ends of wrought-iron pipe?

W. J.

The length of tube end throughout which the screw continues perfect should have an inclination to the axis of the tube of 1 in 32, i.e., a total taper of ¾ in. to the foot.

Effect of Soda Ash on Pump Valves—Will feeding soda-ash solutions through boiler feed pumps injure rubber pump valves?

J. D. R.

A soda ash solution will deteriorate rubber pump valves to some extent, but not seriously when fed along with boiler-feed water in the proportions usually required in a boiler compound.

Overheating Boiler Sheet—In operation of a horizontal return-tubular boiler carrying 125-lb. pressure with two gages of water, is there any possible way the lower part of the front sheet could get red hot?

E. S.

Yes; if the sheet on the inside of the boiler is so covered with scale or other nonconducting material that the heat received by the sheet cannot be transmitted to the water, then, with a hot fire, the sheet would become red hot.

Finding Approximate Temperature of Uptake Gases—How can the temperature of the uptake gases of a boiler be approximately determined without using an ordinary pyrometer or thermometer?

G. N.

The temperature can be approximately determined by noting the effect which the heat of the gases has on small pieces of substances that fuse at different known temperatures when hung on iron wires in the uptake. Fusion of tin occurs at 449 deg. F.; bismuth at 518 deg. F.; lead at 621 deg. F., and zinc at 786 deg. F.

Noise in Flywheel—What may be the cause of a rattling or crunching noise in the flywheel of an engine except when the steam lead of the crank end is late or when the cutoff is earlier on the head end than on the crank end?

W. E. F.

The noise may be caused by a cracked flywheel, or by riding of the key due to improper fitting of the key or to springing of the shaft. Noise from a key will sometimes be stopped by bringing the shaft to rest with the key way at the top and leaving the shaft stand over night with the key way thoroughly flushed with thin lubricating oil.

Measuring Eccentricity of Eccentric—How would the eccentricity of an eccentric be measured?

R. B. C.

Caliper the diameter of the eccentric and the diameter of the shaft, and the eccentricity will be found by adding together one-half of the diameter of the shaft and the distance the "high side" of the eccentric projects from the shaft, and deducting one-half of the diameter of the eccentric; or by adding together one-half of the diameter of the shaft and the distance the "lowest side" of the eccentric projects from the shaft and deducting their sum from one-half of the diameter of the eccentric.

Inch of Mercury or of Water—What is the value in pounds or ounces of pressure per square inch of 1 in. of mercury and of 1 in. of water?

E. P.

The difference in level of water or mercury in the branches of a manometer or U-tube indicates difference of pressure acting on the surfaces of the liquid in each branch and the weight in pounds per cubic inch of the liquid employed will be the difference in pressure per square inch for each inch difference in height, commonly called 1-in pressure of the liquid. At 62 deg. F., 1 cu.in. of mercury weighs 0.491 lb., and 1 cu.in. of water weighs 0.03609 lb., therefore, at this temperature "1 in. of mercury" would represent a pressure of 0.491 lb., or 7.86 oz. per sq.in., and 1 in. of water 0.03609 lb., or 0.5774 oz. per sq.in.

Cast Steel and Steel Castings—What is the difference, if any, between cast steel and steel castings?

A. N. G.

Cast steel is the name usually confined to fine-grained steel from which high grades of cutlery and tools are forged. It is made by cutting up wrought iron into small pieces which are melted in covered crucibles, the desired amount of carbon being placed on top of the charge before the melting, together with any other alloying element desired, such as chromium, tungsten, manganese, etc. After being melted and thoroughly mixed the charge is cast in the form of an ingot for hammering and rolling. Steel castings may be any kind of steel melted down and cast into molds in the manufacture of steam fittings or other articles in the same manner that iron castings are made from iron.

Alternate Firing—What is meant by alternate firing and what are its advantages?

C. J.

Alternate firing consists in spreading fresh coal first on one-half of the bed of the furnace and then on the other half at equal intervals of time, alternating either on the front and rear or on the right and left side of the furnace. The advantages of this method of firing are that the volatile gases arising from each addition of fresh coal are brought in contact with the current of hot gases, carrying an excess of air, which arise from the half-burned coal on the other half of the grate resulting in more perfect combustion of the volatile matter. With a large combustion chamber in which the gases can become thoroughly mixed before coming in contact with the heating surfaces of the boiler, alternate firing, when skilfully performed, may largely prevent smoke.

Steam Supplied to Tenant—Dry steam at 120-lb. boiler pressure is supplied to a tenant for heating the coils of a drying room. There being 850 lb. of condensate returned per hour at the temperature of 212 deg. F., what is the equivalent boiler-horsepower?

W. W.

Referring to the steam tables it may be seen that to raise a pound of water 32 deg. F. into steam at the pressure of 135 lb. per sq.in. absolute (which is approximately the same as 120 lb. per sq.in. boiler pressure) would require about 1192 B.t.u.

The condensate, returned at 212 deg. F., would contain,

$$212 - 32 = 180 \text{ B.t.u. per lb., above 32 deg. F.,}$$

and, therefore, the net service would amount to

$$(1192 - 180) \times 850 = 860{,}200 \text{ B.t.u. per hour,}$$

and as a boiler-horsepower is equivalent to 33,479 B.t.u. per hour, the service would be equivalent to

$$\frac{860{,}200}{33{,}479} \text{ or } 25.7 \text{ boiler-horsepower.}$$

Obtaining Length of New Connecting Rod—How would the correct length of a new connecting rod for an engine be determined from the old rod?

W. H. L.

After properly adjusting the piston rod to the crosshead, the length of new rod should be determined with reference to obtaining equal clearance of the piston at each end of the cylinder. For this purpose, disconnect the rod from the crosshead and make a mark on the crosshead and corresponding marks on the guide when the piston is firmly against first one end and then the other end of the cylinder, the marks thus made on the guide representing the extreme travel of the piston. Next reconnect the old rod and placing the engine first on one center and then on the other, make marks on the guide corresponding to the mark on the crosshead, to represent the length of the stroke. Comparison of the distances apart of the marks made on the guide representing the extreme travel of the crosshead before and after connecting the old rod, will indicate how much longer or shorter the new rod should be between centers of the crank and crosshead pins with equalization of piston clearance.

Engineers' Study Course

Elementary Mechanics--X

Last Lesson's Answers

41. Divide the angle (see Fig. 40) into the two rectangles *OABCO* or *I*, and *DCFED* or *II*. The *c.g.* of rectangle *I* will be at the point *M*, which is the point of intersection of the two diagonals *AC* and *OB*. Likewise, the *c.g.* of the rectangle *II* is at the point of intersection

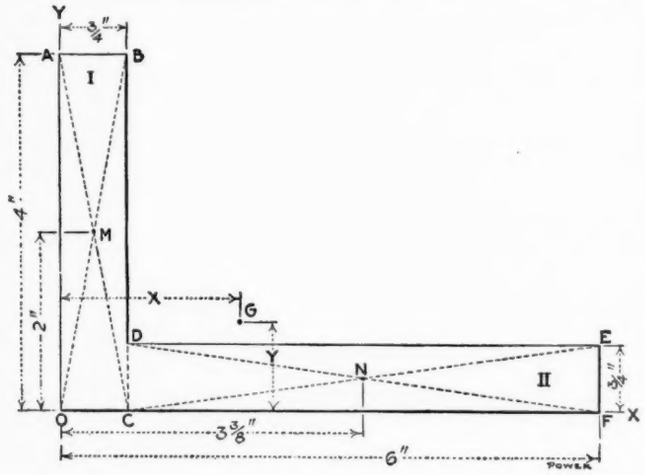


Fig. 40.

N of the diagonals *CE* and *DF*. Draw the reference axes *OX* and *OY*, and assume the *c.g.* of the angle to be located at the point *G*, *X* inches from the *OY* axis and *Y* inches from the *OX* axis. The area of the figure *I* is

$$\frac{3}{4} \times 4 = 3 \; sq.in.$$

and the area of figure *II* is

$$\frac{3}{4} \times 5\frac{1}{4} = 3.94 \; sq.in.$$

Then the total area of the angle is

$$3 + 3.94 = 6.94 \; sq.in.$$

The point *M* is 2 in. from the *OX* axis and 3/8 in. from the *OY* axis; also, the point *N* is 3/8 in. from the *OX* axis and 3 3/8 in. from the *OY* axis. These areas may be substituted in equations (11) and (12) in place of w_1, w_2 and *W* since the weight of the angle is proportional to its area. Thus

$$AX = a_1x_1 + a_2x_2$$

and

$$AY = a_1y_1 + a_2y_2$$

where

$$a_1 = 3 \quad x_1 = \tfrac{3}{8} \quad y_1 = 2$$

$$a_2 = 3.94 \quad x_2 = 3\tfrac{3}{8} \quad y_2 = \tfrac{3}{8}$$

$$A = a_1 + a_2 = 3 + 3.94 = 6.94$$

substituting these values in the above equations

$$X = \frac{a_1x_1 + a_2x_2}{A} = \frac{(3 \times \frac{3}{8}) + (3.94 \times 3\frac{3}{8})}{6.94} = 2.08 \; in.$$

and

$$Y = \frac{a_1y_1 + a_2y_2}{A} = \frac{3 \times 2 + 3.94 \times \frac{3}{8}}{6.94} = 1.08 \; in.$$

42. The beam is in unstable equilibrium.

43. A cylindrical tank lying on its side; (b) the spherical weight used on fly-ball governors, when the weight is resting on a horizontal surface.

44. The *c.g.* should be as low as possible so as to reduce the possibility of overturning the truck when rounding curves.

45. In neutral equilibrium.

Summary of Conditions of Equilibrium

When any number of forces which are either concurrent or nonconcurrent and lie in the same plane, tend to produce a state of equilibrium it has been shown that certain general conditions must be satisfied by the forces. The first of these conditions is that there can be no resultant force. The second of the conditions is that there may be no resultant horizontal, or vertical component, and for this to be true the algebraic sum of all the horizontal and the vertical components must equal zero. If the forces acting on the body pass through a common point the above conditions are sufficient to insure a state of equilibrium; but if the forces are non concurrent then the third condition, that the algebraic sum of the moments of all the forces about a given point must equal zero, is also necessary to completely determine the state of equilibrium. *A system of forces which is in equilibrium may produce either a state of rest, or a state of uniform motion of the body on which the system acts.* Hence the forces acting on a body which is in a state of uniform motion may be in equilibrium just as well as forces which act on a body at rest.

The following general statements will assist the student in summarizing the work of the preceding lessons

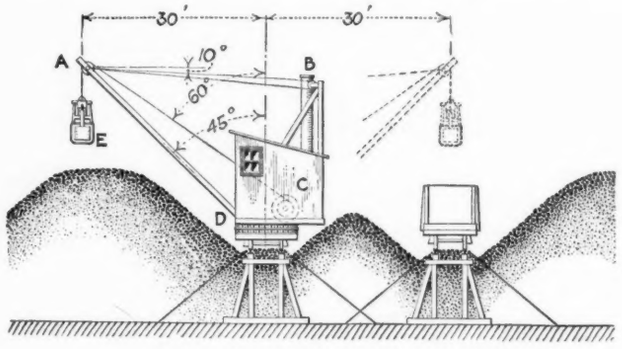


Fig. 41.

and at the same time be an aid in the solution of problems dealing with Statics.

For equilibrium to exist when,

Case I. Two forces act on a body.
The forces must be equal in magnitude, opposite in direction and have a common point of application.

Case II. Three forces act on a body.
(a) *The forces must lie in the same plane.*
(b) *The lines of action of the forces pass through a common point.*
(c) *The three forces may be represented in magnitude and direction by the sides of a triangle taken in order.*

(d) *If the three forces are parallel the resultant force equals zero, and the algebraic sum of the moments of the forces about any given point equal zero.*

CASE III. Any number of forces act on a body.

(a) *If the forces are concurrent and lie in the same plane they can be represented in direction and magnitude by the sides of a polygon taken in order.*

(b) *Any one force is equal and opposite to the resultant of all the other forces.*

(c) *The algebraic sum of the horizontal and the vertical components must equal zero.*

(d) *The algebraic sum of the moments of all forces about any given point must be zero.*

(e) *If the forces are parallel the rule (d) under Case III may be applied.*

It will be noted that in Case I the forces are necessarily concurrent. In Case II the forces may be either concurrent or parallel, and in Case III the forces may be concurrent, parallel or nonconcurrent, and *in all the cases the forces lie in the same plane.*

Problems coming under Case I are solved by making the two forces numerically equal to one another.

Problems coming under Case II are solved, either by applying the law of sines to the triangle of forces, or by the use of equations (8), (9) and (10).

Problems coming under Case II are solved by the aid of equations (8), (9) and (10).

The solution of any problem in Statics may be either analytical or graphical; that is, it may be solved by the use of equations as outlined above, or it may be worked out graphically on the drawing board. The solution of problems by the aid of scale diagrams gives rise to a special form of mechanics called "Graphical Statics," which is particularly applicable to the determining of the loads carried by the various members of roof and bridge trusses, cranes, hoists, etc. While in this course no attempt will be made to discuss "Graphical Statics" it might be well to state that this subject is simply an application of the polygon of forces.

The following study questions are intended to cover the three cases just discussed, to review the work of the previous lessons; further to test the student's ability to analyze his problem, to determine the best method of solution, and last, but not least, to test the student's ability to actually work problems of a practical nature.

STUDY QUESTIONS

46. A boiler stay-bolt makes an angle of 25 deg. with the shell. If the steam pressure is 120 lb. per sq.in. and the stay supports an area 6x9 in., find the pull acting in the stay-bolt.

47. In Fig. 16 (see Lesson IV) let the weight $W = 1000$ lb. and act midway between the points A and B. If the angle $a = 30$ deg., find the tension in the rod AC.

48. In problem 47, determine the direction and magnitude of the pressure at the point B.

49. In the locomotive crane shown in Fig. 41 the total load acting at the point A, due to the weight of the bucket, coal and boom is 4000 lb. The pull in the rope AC is 3500 lb. Find the force tending to crush the boom AD.

50. In problem 49, find the pull in the tie rope AB.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Mebbe, after all, being a mean man has its compensations. This particular feller told his wife that he believed that he hadn't enough friends to make a complete set of pallbearers. His wife told him not to worry. She'd have him cremated and then the ashman could officiate.

Sensible thing that, of opening the Panama Canal when we needed it, rather than waiting later for the fuss-and-feathers brigade to come down in its pomp and complacency. Our critics to the contrary, there are still a few things we get when we want them in good old Unclesamland, by ding!

A surgeon **has discovered** that a boy with the appropriate name of Smart has two appendixes, or appendices, take your choice. Smart boy is Smart, who thus seems to have cross-indexed his table of contents.

Ever pull real hard on your cigar and find that you couldn't even match your smoke with a Ringelmann chart? A bug! Yeppy, it's a tobacco bug, say our national senators. Bet this little cuss is responsible for the "bouquet" (i.e., polite for stink) that emanates from the kind our friends sometimes give us.

Some classy little kid is Constance, on the "foreword" page! Yes, and Chief Hansom would get a blue ribbon in the high-steppers class. But those two Plymouth Rocks in the background! Perhaps the artist meant them as spare parts, or— Anyhow, it's a good picture, notwithstanding, and a credit to our vocation.

Astronomer Charley Naylor, the Marshall Field topnotcher, is some nailer when it comes to our miscalling the heavenly bodies. Chas. says "the Martians live in Mars (if anywhere), and not in our Luna." My stars and Jupiter! We went up in the air when we stated that the moon men were Martians. Guess we'll take a correspondence course from the Lick folks. We're licked this trip, anyhow.

Here's some flattering unction for us practical souls. The national officers of the American Society of Mechanical Engineers are so convinced that the local association is the big means for arousing interest and uplift among professional engineers, that they are going to root tooth and nail for the "locals." You'll learn how they feel about this matter by turning to page 458. Let's see, its some thirty years and more since the national N. A. S. E. officials first started to do this very thing, isn't it? Looks like the "big brother" has got a good hunch.

An editorial in the "Iron Age" contains this slogan: "Back with the saloon!" Who is? If he's the one man in your neighborhood who can concoct a real mint julep or compound a Mamie Taylor, congratulations to you, brother—and here's how! Perhaps, though, we've missed the main idee; whadcha mean, back with the saloon?

"WHY DO I WORK IN A POWER PLANT?"

You have read in other parts of "Power" that it was "your paper as well as ours." This column is no exception, so here's your chance to metaphorically wade in the Spillway. This means everybody, from the oiler and the fireman down to the super, and the owner—if he'll come in.

Write on a postal card a short, original answer to this question:

WHY DO I WORK IN A POWER PLANT?

Then mail it to "Power," mentioning your name and address as an evidence of good faith, not to be published, however, if so requested.

Of course, it won't be original for you to just say "To make a living," "Because I can't get another job," or "Because I've gone crazy with the heat," etc. Make it original first of all, and if it's funny, too, why all the better.

"Power" will give a five-dollar goldpiece for the best answer and the Spillway editor will be the judge. We'll all have five dollars' worth of fun out of this contest, and someone will get real money as well. The contest starts right this minute!

Log for Absorption Plant

By C. W. Harnist

In keeping a log for an absorption refrigerating plant, readings taken every three hours are often enough, because conditions will not change much in a plant ordinarily. Furthermore, taken at these intervals they will not be a hardship on anyone.

DAILY LOG—ABSORPTION PLANT

Date 19

	9:00 A.M.	12:00 NOON	3:00 P.M.	6:00 P.M.	9:00 P.M.	12:00 NIGHT	6:00 A.M.
TEMPERATURES							
BOILER FEED WATER							
BRINE COOLER							
Inlet							
Outlet							
ABS. WATER ON							
ABS. WATER OFF							
GENERATOR							
WEAK LIQUOR							
STRONG LIQUOR							
GENERATOR GRAVITIES							
WEAK LIQUOR							
STRONG LIQUOR							
PRESSURES							
BOILER STEAM							
AMMONIA H.P.							
AMMONIA B.P.							
BRINE							
COOLING WATER							
CITY WATER							
GEN. STEAM							

COUNTER READINGS

AQUA PUMPS
No. 1. Reading ____ Revol. ____
No. 2. Reading ____ Revol. ____
BRINE PUMPS
No. 1. Reading ____ Revol. ____
No. 2. Reading ____ Revol. ____
BOILER FEED WATER PUMPS
No. 1. Reading ____ Revol. ____
No. 2. Reading ____ Revol. ____

ENGINEERS
_____ FM. _____ TO _____
_____ FM. _____ TO _____
_____ FM. _____ TO _____

COAL USED ____
ASHES ____
ICE PULLED ____

CITY WATER METER
Pres. Read. ____
Last Read. ____
Diff. ____

Power

Furthermore, taken at these intervals they will not be a hardship on anyone.

From the data taken on this log the output of the plant may be computed for any length of time. The gravities and temperatures of the aqua will enable one to reduce the data to some standard by reference to ammonia tables, in order to compare one month's run with another. The counter readings of the various pumps allow of computing the amount of liquid circulated, whether it be brine, weak or strong aqua ammonia or boiler-feed water. The amount of ice pulled and the brine circulated will be a check on the quantity of refrigeration produced. The amount of cooling and city water used is important.

From the number of revolutions of the various pumps their total displacement may be easily computed. Their displacement per revolution may be found once and these, times the the number of revolutions, will give their total displacement.

Safety Engineering at the Power Plant

By E. E. Clock

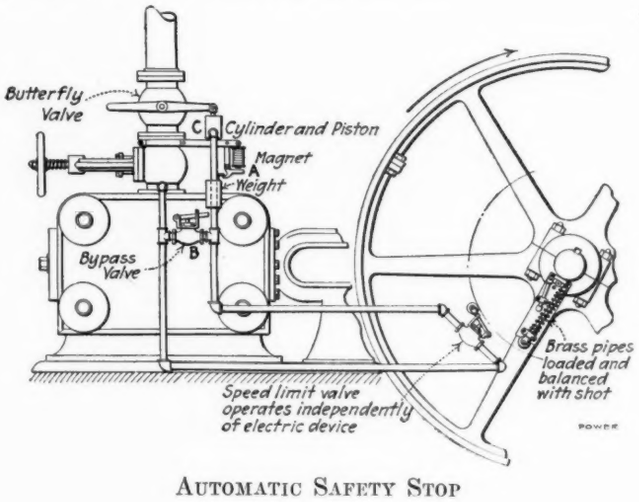
With more than 20 years' experience as an engineer, the last ten as a safety engineer, I have concluded that the public confidence in the engineering profession as a science has been on a basis of faith rather than facts, and that some of the crudities that masquerade as good general practice are little short of criminal.

Regarding safe control of steam engines; the first thought of many, if expressed in words, would be "It's not much of an engineer who can't keep his engine from running away." It is not, however, generally realized that not over 5 per cent. of the steam engines in use are under continual and close manual attendance.

The owner of a plant who would stoutly maintain that his engineer had nothing to do but run the engine might admit under oath that his duties included a great many things, including fixing leaks in the roofs.

Manufacturers locate engines where most convenient, and treat them like other machines; it is not uncommon to find as many as 20 engines located in the plant from the first to the sixth floor, which are visited only periodically and the time between visits is governed only by the capacity of the oil cups.

How are these engines protected against excessive speed and an exploded flywheel? About 50 per cent. of them have no protection at all, about 25 per cent. have an attachment on the governor that is often disabled with the governor, and 25 per cent. are supposed to be protected with some open-circuit electric device that depends upon the integrity of the battery, on open circuit, which in electrical engineering would be a joke, as evidenced by the use of the closed-circuit system on all important work in the electrical-engineering profession, such as burglar alarms, police and fire alarms, ships' signals, etc. Therefore, gross carelessness is found in the matter of safe guarding prime movers against accident.



Automatic Safety Stop

An engine ought to have two chances to save it from being speeded up beyond its safe limits by the steam held in check by the governor valve. One, called the governor, and the other an independent mechanical speed-limit stop, built into the engine and as widely separated from the governor as possible. Work along these lines has recently been taken up by one or two engine builders.

An engine without a reliable safety stop is in exactly

the same position that a boiler would be with a damper regulator and no safety valve, the damper regulator admitting more or less draft, causes more or less steam to be generated and is automatic, but liable to fail. The governor on an engine admits more or less steam to the cylinder and is automatic, but liable to failure. In the boiler the steam to disrupt the boiler must be made, but in the engine it is right there, pushing hard against the governor valve. A safety valve is provided for the boiler, but there is no safety stop for the engine unless put on after leaving the builders. No one would think of locating a boiler in a remote part of the plant with no attendance to speak of, with no safety valve, fed by a mechanical stoker, and controlled only by a damper regulator, but this is done in the case of the engine.

There are two ways by which the present installations of open-circuit electric stop can be made worth while; one is to change it to the closed-circuit system so that its integrity remains visible and its failure must be a self-demonstrating fact as against the invisible, unsuspected failure that does not show up except on test or trial. The other way is to replace the batteries with a generator, then provide a red pilot lamp in the circuit so that when located behind a reflector it will be noticed at once if the current fails.

Some months ago I was called upon to design a safety stop for one of the large steel plants and evolved the one shown herewith. This stop provides for push buttons if desired, but the electric stop is auxiliary to the main stop. The small weight *A* which is released by the magnet is made with a hole through its length and slides on the pipe, as shown. When released by the magnet it slides down the pipe and striking the lever of the valve *B*, opens the bypass valve. The cylinder *C* and its piston, provided to open the butterfly valve, may be used to unhook the lever and the valve closed by a weight on the other end of the lever; this cylinder and piston may be arranged to push the governor up to the top where no butterfly valve is provided.

If the speed-limit valve is made self-closing it simply jumps the butterfly valve shut by short jumps at each strike of the roller on the wheel hub until the wire drawing cuts the speed below the striking speed, and does not stop the engine. With a valve that stays open when struck or with a butterfly valve closed by weight, the engine will come to a standstill after over speeding.

A Short-Sighted Engineer

By H. L. Lax

The many articles published in the technical press today about the success or failure of the operating engineer and the lack of proper compensation bring to mind a case of extreme short-sightedness on the part of an operating engineer which came to my notice some time ago. This engineer was chief of an isolated plant of some 300 hp. in a moderate-sized store building in a large Western city. Plans were under way to more than double the size of the building and at the same time to erect a larger power plant in a new location to take care of the increased requirements. It was natural that this engineer should look forward to the new plant and the probable raise in salary.

About this time the central-station men became interested and seeing the opening went after the business in their usual aggressive manner. A consulting engineer was called in by the store management and reports were submitted from both sides. On a basis of costs the proposition was so evenly balanced that for several months the argument continued with about equal chance for settlement either way.

Of course, the consulting engineer and the central-station men went into the existing plant for data upon which to base their reports and estimate the requirements of the enlarged plant. What records had the engineer kept? Practically none. He had read the integrating watt-hour meter once a day and remembered what the peak load had been during the busy season. He had some indicator diagrams taken for the purpose of valve setting and on a few of these the engine speed and the load had been noted, but they had never been worked up to determine the indicated horsepower. At one time he had weighed the coal over a period of a few hours, but not the feed water. Outside of this there were only the monthly coal and labor bills in the office.

Investigation showed a reasonable economy, but at the same time there were a number of small losses that could have been detected if the most elemental records had been kept. Furthermore, it was not lack of ability on the part of the engineer but the attitude of "what is the use of worrying over today when tomorrow will bring a new plant." In this connection he had condemned all the old equipment and expected that a complete new installation would be made. In fact, the engines, generators, etc., were not half old enough and in far too good condition for the scrap-heap. As spare equipment in the new plant they would have kept down the investment outlay materially.

When the chief saw that everything was not "clear sailing" for him and about the time the first reports were made he took a big jump at conclusions. All that he could see was a sure fate for the isolated plant and the advent of central-station power. This did finally turn out to be the case, but not for nearly three months later. In the meantime the plant was sorely neglected with the result that a finer collection of pounding and leaks would be hard to find under one roof. It was hard to realize that a plant could deteriorate so much in so short a time. A few of the worst leaks had been smothered more or less with old rags and waste.

Taking the engineer's point of view when he decided on his own hook that the isolated plant was doomed, there were two prospects for him: first, to get a new position when the opportunity offered; and, second, to stay on the job after the change was made. In either case, what could he possibly gain by following the course he did? His employer could not consider him a fit man for continued employment, and could not honestly give him a strong recommendation to others.

The Electrical Conductivity of copper depends upon the total amount of impurities and not upon any one element. That is why the conductivity test is so valuable in determining the purity of copper. The aggregate of all impurities is shown and thus the purity of the copper indicated. Amounts of impurities that will defy detection, or would never be known to exist by chemical analysis are found when the electrical conductivity test is applied. It can be considered one of the most valuable tests known in metallurgy.—"The Brass World."

Recent Court Decisions

Digested by A. L. H. STREET

Judicial Power Concerning Public Service Rates — Although a court has power to enjoin enforcement of an ordinance which fixes rates to be charged by a public service corporation so low that they are unreasonable and confiscatory, it is not authorized to fix a reasonable rate, according to the decision of the United States District Court for the Northern District of California, in the case of Pacific Gas & Electric Co. vs. City & County of San Francisco, 211 "Federal Reporter," 202.

Power as Part of Public Improvement—In holding that a public ditch contractor's bond to pay for all "material furnished" under a contract for the construction of a drain secures payment for fuel used in the work, the Minnesota Supreme Court recently said:

Power must usually be generated in ditching and we think liability should not be restricted to items actually entering into the completed structure. It is sufficient if the materials be reasonably incident to the performance of the particular contract. (Fay vs. Banker's Surety Co., 146 "Northwestern Reporter," 359.)

Stringing Electric Power Wires near Telephone Lines—It is actionable negligence for a company to string uninsulated high-tension wires within 18 in. above telephone wires, if a telephone lineman is injured through coming in contact with one of them, while in the performance of his duties, and in the exercise of due care for his own safety. Since he has no contractural relations with the electric company, he cannot be deemed to assume the risk of such an accident. (Michigan Supreme Court, Teachout vs. Grand Rapids, G. H. & M. Ry. Co., 146 "Northwestern Reporter,"

Responsibility for Defective Steam Valve—In a recent suit brought to recover damages for death of an engineer in an industrial power plant, caused by the coming off of a bonnet on a steam valve, allowing steam to escape, the Massachusetts Supreme Judicial Court sustained the right to recover on the grounds that decedent did not assume the risk of such an accident, and was not guilty of contributory negligence, and that the employer was negligent in failing to discover and remedy the defective condition. Incidentally, the court finds that the testimony of a state boiler inspector that he would not have gone into the boiler room and attempted to move certain bolts on the valve, if there were 80 lb. of steam on the boiler, even if he was in a "four-acre lot and could run away," was properly excluded. The court says: "It was immaterial what Sullivan would have done, and yet more immaterial what he might have said that he would have done." (Loftus vs. Fall River Laundry Co., 104 "Northwestern Reporter," 575.)

Liability for Boiler Explosion—These facts were held by the Pennsylvania Supreme Court in the recent case of Hitchman vs. H. S. Kerbaugh, Inc., 89 "Atlantic Reporter" 669, to be insufficient to establish liability of the defendant company for fatal injury to an employee, caused by the explosion of a boiler used in construction work. There was no evidence to show how long the defendant had owned the boiler, if the company owned it at all; nor how long the boiler had been used; nor that the company had failed to make proper inspection of it. The proof was just as consistent with the defendant's theory that the accident occurred through the decedent's failure to keep the boiler supplied with water, as with the plaintiff's theory of negligence attributable to the company. The evidence showed that the parts which were claimed to have been defective were intact after the explosion, and that the part that blew out was in close proximity to the point where danger would result if water were suddenly turned on after permitting it to run too low. The court further finds that the plaintiff was not entitled to show that, when found in a dying condition, decedent said that he did not know how the accident happened, that he "had plenty of water and plenty of steam," that statement amounting to a mere conclusion.

Liability Concerning Electric Wires—The appellate courts of the country are called upon every month to reaffirm the liability of electric companies for injuries to persons accidentally coming in contact with high voltage. Among the latest cases on this subject are McCrea vs. Beverly Gas & Electric Co., 104 "Northeastern Reporter," 365; and Spencer Light, Power, Heat & Water Co., vs. Wilson, 104 "Northeastern Reporter," 94. In the first case, the Massachusetts Supreme Judicial Court holds that an electric company was guilty of actionable negligence in maintaining uninsulated high-voltage wires in close proximity to trees which it was known to be necessary for municipal employees to climb in performing certain duties. In the other case the Indiana Appellate Court decided that an electric company which negligently permitted high-voltage wires to remain near a rotten telephone pole in such position that when the pole fell over it broke one of the wires, which was thus permitted to come in contact with a nearby wire clothes line, is liable for injury to one who attempted to use the clothes line, although the company cannot be presumed to have foreseen the particular accident. The court says:

It has long been settled law that when one conveys through the streets and alleys of a municipality a substance which is known to be as dangerous as electricity, he is charged with exercise of the highest degree of care to see that it does not escape so as to injure life or property.

Water Power Rights Subject to Condemnation—The right of a city, in providing a water supply for its inhabitants, to condemn water rights previously acquired by a water power company is recognized by the United States District Court for the Northern District of Ohio, in the case of Cuyahoga River Power Co. vs. City of Akron, 210 "Federal Reporter," 524. But it is also held that the city is not entitled to condemn any such rights without first paying due compensation therefor. On this important question, the court says:

The plaintiff is a private hydro-electric corporation organized under the general laws of Ohio; having been granted its charter it had the right to be a corporation; and, except so far as limited by law, it had the right to proceed, as it saw fit, by appropriation or otherwise, with the accomplishment of the purposes which it has itself declared. It is not by virtue of its incorporation or of its franchise bound to carry out its scheme of development. A large number of cases have been cited in support of the doctrines that, by virtue of its adoption of plans, the company has thereby acquired a right to appropriate the property of others included in this plan, and that this right has thereby acquired a priority over all others, except the state acting directly upon this property. This might be true as between private corporations; but as between a private corporation vested with the right of eminent domain for the carrying out of the purposes of a quasi public nature and the subdivision of a sovereign state, like a municipal corporation, which exercises the power of eminent domain to carry on the vital needs of its population for a supply of water for domestic purposes, this priority cannot exist. The municipality is given a paramount right to appropriate property needed for that purpose, although the same property has become the subject of earlier appropriation proceedings by a private corporation.

Incidentally, the court concludes that the decision of the municipal authorities as to the actual necessity for appropriating the waters of the stream for municipal purposes cannot be disturbed by the courts, in the absence of a showing of bad faith in the matter.

A Municipal Electric Plant in Trouble

There was much local discussion in connection with the municipal electric-light plant of Kansas City, Kan., which failed to furnish the customary "juice" for several nights during the latter part of February. From the daily press it appears that the interior of the turbines became incrusted with a scale from impurities carried over by the steam from the boilers. An attitude of suspicion and suggestions of vandalism were indulged in freely.

A contributor assures us, however, that the conditions were not in any way unusual or necessarily involved beyond keeping the boilers clean, or better yet, purifying the feed water coupled with frequent inspection of the machines.

Oil-Engine Flywheel Explodes

On May 13, the flywheel of a 30-hp. horizontal crude-oil engine at the works of the Carbo Steel Post Co., in Chicago Heights, Ill., burst into a dozen pieces, killing one man instantly and slightly injuring another.

Since its installation three months ago, the engine had been run day and night, driving by belt a small generator furnishing current for galvanizing purposes and also a line shaft for general power purposes. The engine cylinder was about 9x14 in. The flywheel was 5 ft. in diameter, weighing 1500 lb., and as the speed of the engine was 250 r.p.m., the peripheral velocity would be 3927 ft. per min. The rim was 8 in. wide, 1¾ in. thick at the edge and the webb 4½ in. deep. It was supported by six spokes.

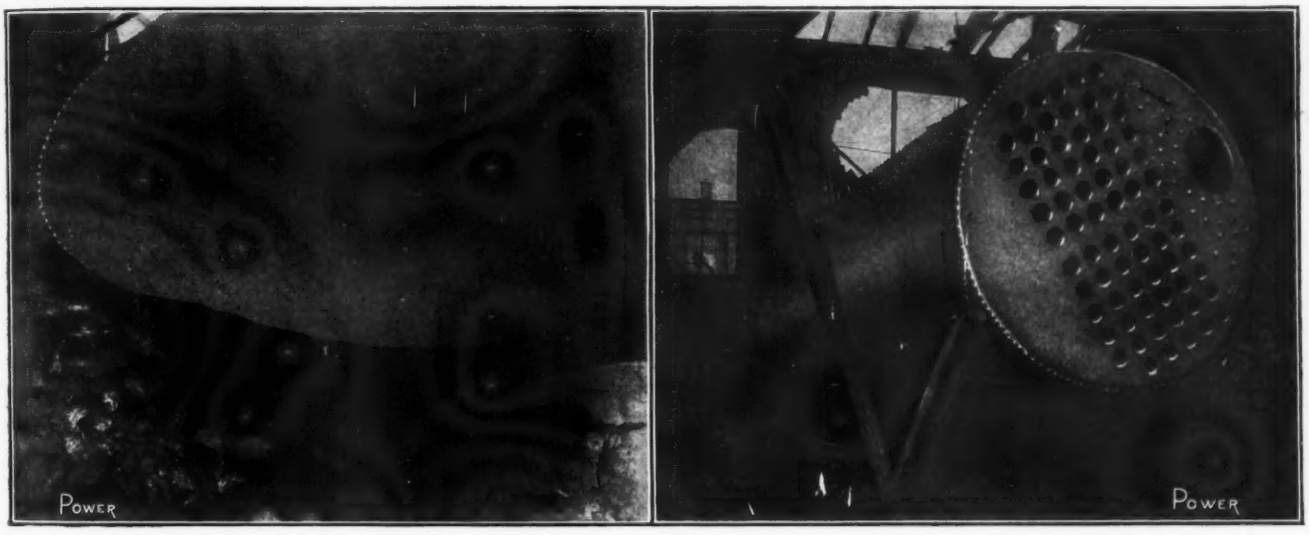
At three o'clock in the morning, when the accident happened, the engine was running along smoothly and without any apparent cause the flywheel suddenly let go. With the exception of a couple of small blowholes in the rim, there did not appear to be any defects in the metal. The cause was not apparent, and it is only a surmise that the blowholes weakened a wheel which was light for the service, sufficiently to cause the accident.

A Return-Tubular Boiler Explosion

The photographs reproduced are intended to show the extent of a fire-sheet failure in a return-tubular boiler at the Bellevue, Ohio, electric-light plant several weeks ago. The boiler was rated at 125 hp., and carried 100-lb. pressure.

Our correspondent stated that "a close examination along the line of rupture showed a flaw (evidently an old one) in the material from the inside about half through the thickness of the sheet. In my opinion the flaw was so situated that an inspection could not disclose it even if it had been possible to get into the boiler below the tubes. There are no evidences of lack of water, no blisters, bags or indications of overheating. The cause was, I believe, structural weakness of the sheet."

Two lives were lost, as well as considerable property, as a result of this accident.



SHOWING THE EXTENT OF THE RUPTURE

Explosion Aboard the "Jefferson"

Late in the night of May 11, as the steamer "Jefferson" of the Old Dominion Line was off Cape Henry, the top afterside of the back sheet of the after starboard boiler (Scotch marine) gave way. The normal pressure is 190 lb. Eleven men are dead as the result of the accident: William L. Portlock, of Brooklyn, chief engineer; H. B. Smith, first assistant engineer; four firemen, three coalpassers, one oiler and one water tender. Mr. Portlock had been in the company's service for more than thirty years. The vessel was towed into Norfolk by a wrecking tug.

In the boiler room are eight Scotch marine boilers. The firing aisle is about 40 ft. long and less than 15 ft. wide. There are but two exits, one a small doorway aft into the engine room, the other an iron ladder at the forward end. The injured boiler is the first to the right (or starboard) as one stands in the small doorway connecting the engine and boiler rooms. The boilers were built in 1899 and put into the "Jefferson" when new; the tubes are 3½ in. in diameter.

Although 190 lb. is the pressure usually carried, it is probable that at the time of the accident it was about 160 lb. as the ashes were being taken out and the pressure aboard this ship invariably dropped 30 lb. during their removal.

The tube sheet that let go did not tear away at the combustion chamber, but completely away from twelve tubes, forming a belly in the sheet. The sheet has a belly covering the area occupied by twenty-four tubes, the remaining twelve being only partly pulled away. The boilers are set athwartship—at right angles with the length of the ship. That the tube sheet was not badly burned is indicated by the fact that the belly was driven back with jacks and the sheet straightened preparatory to putting in some new tubes. The crown sheet sagged, indicating low water.

The "Jefferson" was taken out of service the first of the year and was undergoing repairs for six weeks. During that time eight new furnaces and ninety new tubes were put in, the boilers receiving an inspection at the time by the Government inspectors.

Nearly all of those who died dropped on the slippery iron engine-room floor just outside the boiler room. Two or three made their way to the main deck, where the officers and passengers had difficulty in restraining them from jumping overboard, so maddened were they by their burns. One fireman crawled into the bilge hoping to relieve his suffering by lying in the water. He died, the body not being found until the vessel reached New York.

The chief and the first assistant hastily made their way to the boiler room when the explosion occurred, hoping to save the injured. They were overcome and so severely burned that the assistant died two days later and the chief one week afterward, so that all of those in the boiler and engine rooms at the time have met their death.

Los Angeles for Municipal Ownership

The electors of Los Angeles, Calif., by a vote of 56,199 to 23,179, on May 8 authorized the issuance of $6,500,000 of bonds for the completion of a hydroelectric generating station and for building or taking over an electric distribution system.

The City Council refused to permit the question to go upon the ballot in a segregated form, namely, $1,250,000 for the completion of the generating station, upon which $3,500,000 has already been expended, and $5,250,000 for a distribution system. The three electric companies in Los Angeles offered to buy the energy produced at the aqueduct plant at a price to be fixed by the state railroad commission, the city to fix the price at which the energy would be resold to consumers, but the offer was rejected.

It is reported that the intention of the city's administration is to acquire a distributing system by eminent-domain proceedings. It is believed that these proceedings will be contested to the limit.

Plan to Centralize London's Electricity Supply

The centralization of the electricity supply for London, England, has been recommended in a recent report to a special committee of the London County Council by C. H. Merz

and W. McLellan, consulting engineers. They point out that the present position of the supply services is unsatisfactory as the result of a Parliamentary policy of encouraging the formation of numerous small competitive undertakings. After studying the amount and variety of the future demands of the whole metropolitan area, these engineers estimate the output needed in the near future at twenty times the present. They do not consider the enlargement of any of the existing stations in this district economical or desirable.

Messrs. Merz and McLellan recommended instead a concentration of a number of large generating stations on neighboring sites, 10 or 12 miles down the Thames. This would be under a new organization amalgamating all the old undertakings. Power would be distributed over the existing networks where possible and elsewhere supplemented by a new three-phase network; there would also be standardized a high-voltage, three-phase, 50-cycle, primary-distribution system. The immediate outlay required is estimated at some $35,000,000. The annual saving over the development of existing plant is estimated at $850,000.

Meeting of Chicago Section A. S. M. E.

"Machine Shop and Machine Tool Practice" was the topic for discussion at the last meeting of the season for the Chicago section of the American Society of Mechanical Engineers, held in the Crystal room of the Hotel Sherman on the evening of May 13. Fully 150 were at table and all were enthusiastic over the distinguished list of sqeakers, which included James Hartness, president of the society; Calvin W. Rice, secretary; Dean Goss, of the University of Illinois; Robert W. Hunt, P. W. Gates and A. M. Houser.

Chairman Bird officiated and made a few introductory remarks on the work of the local committee. The organization was only a child two years old. The committee at first did not know what was wanted, and it was not until the last of the five meetings held last year that the section really found itself. This was a dinner meeting, and it was the first at which good fellowship appeared. This plan was continued, and no doubt has been largely responsible for the decided success of the meetings this season. Two things have been kept in mind: sociability and the best speakers that could be found.

Secretary Naylor spoke briefly on money matters, after which the following officers were elected for the ensuing year: Samuel G. Neiler, Rich & Co., consulting engineers, chairman; H. M. Byllesby, president of H. M. Byllesby & Co., vice-chairman; H. M. Montgomery, Permutit Co., secretary and treasurer; P. A. Poppenhusen, president of the Green Engineering Co., and H. S. Philbrick, professor of mechanical engineering at Northwestern University, other members of the committee.

Dean Goss stated that the engineer more than at any previous time is a conspicuous figure. His influence is broadening and reaching out into all walks of life. To develop the engineer must affiliate with other members of the profession. It is worth while for one who is trying to do something to have good help by his side. He was delighted with the good work being done by the Chicago section and asked for an expression of appreciation of the executive committee. As to the topic of the evening it was his thought that the development of the machine tool typified the development of engineering progress. On the trip abroad he was impressed with this fact. At some of the largest works the management would say: "Here they are! We have got them!" as though attributing their greatness to the American machine tool.

President Hartness brought the greetings of the national body to the Chicago section. All at the home office have the Chicago section in mind, and it is their desire to keep in closer touch with the local organizations. It was his hope that the section would build up to greater proportions and that more of the members would be seen at the national gatherings. In his preliminary remarks President Hartness spoke of the advantages of getting together; it helps in engineering work, and the engineer cannot work as a hermit. Evenings such as this are fruitful in inspirations which aid in doing better work. Success comes from contact and without it mediocre results are to be expected. The speaker emphasized the need of specialization and of knowing more than straight engineering work. Primarily, the engineer is a director of men and must know his fellow creature. If he fails to learn how he can work most efficiently, he is missing much. The human being is a creature of habit and works most efficiently along habit lines. The more we can do to allow him to work along these lines, the more we are doing for our fellowman and for the general advancement of the profession.

A. M. Houser, mechanical engineer of the Crane Co., presented a short paper on "Designing the Product." Too little attention had been given to this subject. The master mind in a flash of genius might invent a machine or a particular piece of apparatus, but improvement requires hard work and close attention to details. Standardization was of great importance and simple systems of working for each department. It was his opinion that a general system should be developed covering all engineering office work. It was just as important as for any other department. With such a system in force, the engineer, in passing from one company to another, need spend but little time in learning the details of the business. It was gratifying to the speaker to announce that one standard for flanged fittings had finally been agreed upon and that the matter was to come before the spring meeting. The standard for pipe threads was also mentioned, and, besides, a standard for gate valves which had recently been adopted by the underwriters.

P. W. Gates spoke of the early days of machine-shop practice, including a mention of the first die used for cutting a pipe thread, Chicago's first locomotive, some old-time steam hammers and other interesting examples of the work done in the early days.

A few extemporaneous remarks by Capt. R. W. Hunt left the gathering in a happy frame of mind to listen to the home secretary, Calvin W. Rice, who had come all the way from New York for the meeting. His catchword was the human side. The Chicago section had developed it and that was the reason for its success. Participation of members holds the interest and informal gatherings get the men to their feet. The Chicago section has a great opportunity as the home city is destined to be the largest on the continent. It has the chance to put the society in a position it does not occupy today. The local organizations have proved to be the life of the society and are what is making it worth while. There are now 12 or 14 places in which meetings are held regularly, and as soon as conditions warrant the number will be increased. Mr. Rice went into detail on the work at the home office and assured his listeners that if help were needed they would find him at the other end of the wire.

BOOKS RECEIVED

COMPRESSED AIR. By Theodore Simons. McGraw-Hill Book Co., New York. Cloth; 167 pages, 5¾x9 in.; 42 illustrations; tables. Price, $1.50.

ELECTRIC LIGHT ACCOUNTS. By H. M. Edwards. McGraw-Hill Book Co., New York. Leather; 172 pages, 4¾x7¼ in. Price, $2.

HYDRAULICS. By Ernest H. Sprague. Scott, Greenwood & Son, London, England. American agents, D. Van Nostrand Co., New York. Cloth; 184 pages, 4½x7¼ in.; 89 illustrations; tables. Price, $1.25.

STEAM TURBINES. By James A. Moyer. John Wiley & Sons, Inc., New York. Second edition. Cloth; 376 pages, 6x9¼ in.; 225 illustrations; entropy total heat chart. Price, $3.50.

STEAM PIPES. The Vulcan Boiler & General Insurance Co., Ltd., Manchester, England. Cloth and paper; 120 pages, 5¼x8¼ in.; 62 illustrations. Price, one shilling.

ENGINEERING AFFAIRS

The annual convention of the Special Libraries Association, affiliated with the American Library Association, will be held in Washington, D. C., on May 27 and 28. This association is chiefly composed of the business libraries with engineering, commercial, industrial and financial interests.

A meeting of the Engineers' Club of Cincinnati was held in the Literary Club Rooms Thursday, April 23, at which the following papers were presented. "The Beginning and Growth of the Machine Tool Industry in Cincinnati," by A. Lewis Jenkins; "Material and Construction in Local Reinforced Concrete Work," by Ludwig Eid. A paper on "Recent Development in Smoke Abatement," by A. G. Hall, was postponed to a later meeting.

Announcement has been made of the Oil Mill Superintendents' Convention to be held in Columbia, S. C., June 2, 3, 4 and 5. Headquarters will be at the Jefferson Hotel, and the exhibits and meetings will be held at the fair grounds, about two miles from the city. Special attention is called to the exhibit of machinery, since it will be of as much interest to power plant engineers and owners as to oil mill super-

intendents. Some of the largest makers of valves, fittings, pipe, belts, lubricants and other power plant equipment will be among the exhibitors. This will be the first exhibition of power plant equipment at these conventions, and operating engineers are invited to avail themselves of this opportunity.

The midsummer meeting of the American Society of Heating and Ventilating Engineers will be held in Cleveland, Ohio, July 9-11. Headquarters will be at the Hotel Statler. One of the features of the meeting will be an all-day trip on one of the large Lake Erie steamers, with a professional session held on board, followed by a dinner in the evening and other entertainment. In addition to the usual number of papers, the program for the meeting will include interesting committee reports on car ventilation, radiator location, special fan application, elimination of noise, chimneys and draft, industrial building installations. The Cleveland committee which is making the local arrangements for the meeting, is composed of Frank G. Thegley, 706 Rose Building, chairman; J. H. Bacon, Jr., W. M. Kingsbury, R. S. Mayer and F. H. Valentine.

Over 400 men of the various scientific and engineering societies united in a mass meeting and smoker on the roof garden of the Continental Hotel in Philadelphia, Friday evening, May 15. J. A. Vogleson, chief of the Bureau of Health, acted as toastmaster, and the address of welcome was made by Hon. George W. Norris, Director of Wharves, Docks and Ferries. The other speakers were Dr. W. W. Keen, president of the American Philosophical Society, who spoke on scientific societies; Dr. Walton Clark, president of the Franklin Institute, whose subject was "The Franklin Institute and the State," and Dr. Alexander C. Humphreys, president of Stevens Institute of Technology, who, in discussing "The Engineer as a Factor in Modern Progress," found the opportunity to voice again his plea for engineers on Public Service Commissions.

The Brooklyn Edison Co. has opened its new athletic field for the Brooklyn Edison Employees' Association, which numbers more than two thousand. It is known as the West End Oval, and is located on the water's edge. Experts regard it as one of the best equipped athletic parks in the city. The grounds can be reached direct from the company's headquarters in Pearl St. in 25 minutes. The diamond is dirt, with a grass outfield. The stands will accommodate more than three thousand spectators.

W. F. Wells, vice-president, and P. R. Atkinson, treasurer, are both greatly interested in the field, and it was largely through their efforts that the new athletic grounds were made possible. Mr. Wells, in speaking of the new field, said: "I feel certain that the grounds will be a great boon to the employees of the company. The field will furnish them with an excellent opportunity to get out in the open air after business hours. It is one of the best in the city and can be reached for one fare from all parts of the borough. This should be an inducement in itself to stimulate interest in bringing out the members of the association every Saturday. Improvements are to be made as the season advances, and I feel certain that it will be a great athletic year." A hotel adjoining the grounds furnishes opportunity for dancing. Bathing may be enjoyed by members of the association, as there are bath houses adjoining the park.

The athletic committee is W. T. Fairbairn, chairman; P. D. Sharkey, H. P. Wood, J. C. Van Duyne, E. W. Babcock, C. E. Butz and W. Eichert.

PERSONALS

William O'Hallaren, chief engineer and chief electrician of the Newmarket (Ont.) Municipal Electric Light & Water-Works, has tendered his resignation after 17 years of service.

Arthur Cushing has been appointed operating engineer of the Clinton (Ill.) Gas & Electric Co. He was formerly with the Decatur Railway & Light Co. and other Illinois Traction properties.

H. M. Wall, who for the past year has been connected with the Memphis Street Railway Co. as assistant chief engineer of power stations, has become associated with the firm of Ruebel & Wells, consulting mechanical-electrical engineers, Chemical Building, St. Louis, Mo.

Foster Hannaford has been appointed acting general superintendent of the Galesburg Ry., Lighting & Power Co., Galesburg, Ill., vice Mr. Dickerson McAfee, now on a leave of absence. Mr. Hannaford has been operating engineer of the company, which is one of the subsidiaries of the Illinois Traction System.

OBITUARY

MARTIN DELANEY

On May 10, Martin Delaney, an engineer in the plant of the Wilkes-Barre Co., Wilkes-Barre, Penn., died as the result of injuries sustained by a fall from a ladder into a 14-ft. pit. Mr. Delaney was 35 years old, and for nine years was in the employ of the Wilkes-Barre Co., the officials of which speak highly of his services. He leaves a widow and two children.

WILLIAM F. CRANE

William Franklin Crane, member of the family known all over the country as engineers, died on May 18 from heart disease after a three-years' illness, at his home, 260 East 19th St., Flatbush, New York City. He was a nephew of the late Archie Crane, the Chicago iron magnate, who died last winter. Mr. Crane was born in Chicago 55 years ago, a son of the late Franklin Crane. His father was one of the three Crane brothers who founded the Crane Co., and in early life he joined the company, and came to New York to manage the Eastern business of the firm. Some ten years ago he went in the same business for himself with offices in the Singer Building. He was until recently a member of the Long Island Automobile and other clubs, but because of ill health had resigned. He is survived by a widow, who was Miss Mary Carter, of St. Joseph, Mo. Interment will be made at Chicago.

JOHN J. C. SMITH

John J. C. Smith, inventor of machinery for making insulated wires and compression castings, died at his home in Passaic, N. J., on May 11. He was 79 years old. Born in Bavaria, he came to America with his parents when still a boy, passing the greater part of his early life in Boston. In 1883 he came to Passaic and later founded the Okonite Co. One of his patents for making dies for coins and stamps was bought many years ago by the Government and is still being used in the Mint.

Mr. Smith was associated with leading American capitalists, manufacturers and inventors through his inventions, among them being Thomas A. Edison in his early days and Alexander Graham Bell, inventor of the telephone. He was instrumental in forming the first telephone company in America.

He leaves nine children.

JOHN ERWOOD

John Erwood, consulting mechanical engineer and inventor, died at his home in Chicago, Ill., on Apr. 14, at the age of 54.

Mr. Erwood was born in London, England, and came to this country at the age of 20. He worked diligently in New York City for a few years, then went to Chicago, where he established himself as a consulting engineer, engaging in an active and successful career until his death.

Twenty-five years ago Mr. Erwood became consulting engineer for the Gormully & Jeffery Co., Chicago, which later merged into the Thomas B. Jeffery Co., Kenosha, Wis. The complete factory which this company occupies has a floor area of 500,000 sq.ft. and was designed and built by Mr. Erwood. The power plant, having about 4000 hp., was installed by him as well as the complete heating system and other plant details.

Mr. Erwood not only attained success as a consulting engineer, but distinguished himself as an inventor. His most notable achievement was his invention of the Erwood double-acting nonreturn steam valve, now manufactured by the Crane Co., Chicago, and known as the Crane-Erwood nonreturn valve. Another invention was the Erwood swing gate valve, manufactured by the Nelson Valve Co., Pittsburgh, and known as the Nelson-Erwood swing gate valve. Mr. Erwood was also the patentee of a blowoff valve, a noncorrosive fire-door and a water-tube boiler.

Kindness, honesty and charity were conspicuous phases of the character of John Erwood, for his heart was big and he gave with a free hand. He leaves a widow and five children.

Cause of Stay-Bolt Failures—The service which a stay-bolt is called upon to perform is a trying one. The most prolific cause for stay-bolt failures is to be found in the repeated bending stresses set up by the unequal expansion of the sheets which they support. A tough, ductile material has been found to be best suited to this service, even if toughness is secured at the expense of tensile strength.—"The Locomotive."

BUSINESS ITEMS

Newton L. Schloss, mechanical and electrical expert, has removed his office to 25 West 32d St., New York.

The Magnolia Metal Co., 112 Bank St., New York, is sending out an interesting war map of Mexico, 14¾x11 in., free of charge upon application while the supply lasts.

Charles Enderle, formerly with the Harrisburg Foundry & Machine Co., is now associated with L. Copleston, Inc., 39 Cortlandt St., New York., selling exclusively the Ball engine of Erie, Penn.

The series of gas-engine data cards put out by the Bruce-Macbeth Engine Co., Cleveland, will be found extremely useful by any engineer. These cards are in the form of actual blueprints, and give really valuable data on the operation, construction and design of gas engines. Until the supply is exhausted, this series of cards may be obtained without cost by writing the Bruce-Macbeth Engine Co., 2107 Center St., N. W., Cleveland.

At the annual meeting of the stockholders of the Joseph Dixon Crucible Co., held at the company's main office in Jersey City, N. J., on Monday, Apr. 20, 1914, the retiring Board of Directors, consisting of Geo. T. Smith, William Murray, George E. Long, Edward L. Young, William G. Bumsted, J. H. Schermerhorn and Harry Dailey, were unanimously reëlected. The officers of the company, consisting of George T. Smith, president; George E. Long, vice-president; J. H. Schermerhorn, treasurer; Harry Dailey, Secretary, and Albert Norris, assistant treasurer and assistant secretary, were also reëlected.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Bangor Ry. & Electric Light Co., Bangor, Maine, contemplates extending its system. New waterwheels and generators, costing $28,500, will be installed at the Veazie power station.

The Union Knitting Mills, Pottsville, Penn., contemplate installing an electric-power plant. J. I. Reed is the owner.

SOUTHERN STATES

It is reported that the Mountain Milling Co., White Sulphur Springs, W. Va., will remodel its electric-light plant and install new equipment.

The Center Falls Power Co., Center Falls, N. C., will erect a plant. J. B. McCrary Co., Atlanta, Ga., has been engaged to take charge of the work.

The Tatum Bros. Real Estate & Investment Co., Miami, Fla., contemplates constructing a power plant.

The Lebanon Milling Co., Lebanon, Ky., is in the market for motors. The company is equipping a plant for the manufacture of flour.

The City of Louisville, Ky., will install boilers for the heating plants of the Boys' High School, estimated to cost $300,000; Ward & Glossop, Joseph & Joseph, and John B. Hutchings Schools, estimated cost, $100,000 each.

The Harlan Coal Mining Co., Louisville, Ky., which is equipping a new operation at Coxton, Ky., is buying power equipment through Frank Sneed, general manager, Coxton.

CENTRAL STATES

The power and light plant of E. K. Gardner, at Shreve, Ohio, was destroyed by fire Apr. 29. Estimated loss, $10,000.

The City Council, Youngstown, Ohio, has appropriated $3000 to employ an engineer to erect a municipal electric-light plant.

The Alma Illuminating Engineering Co., Alma, Mich., will erect a power plant at Riverdale. H. S. Conner is engineer-in-charge.

The Electric Light Commission, Crystal Falls, Mich., will purchase one 200-kw., three-phase, 60-cycle, 2300-volt generator. J. H. Sanders is superintendent.

A company is being organized by the business men of Rankin, Ill., for the purpose of erecting an electric-light plant. S. Johnson is interested.

At a recent election, it was voted to erect a municipal electric-light plant at Sheldon, Ill.

The Spring Valley Gas & Electric Co., Spring Valley, Ill., will install a 300-kw. generator.

The power plant and mill of the Bark River Electric Light & Power Co., and the Rome Roller Mills Co., Rome, Wis., were recently destroyed by fire. Estimated loss, $25,000.

WEST OF THE MISSISSIPPI

The City Council of Valley Falls, Kan., will buy new engines and generators for the municipal light plant.

The electric-light committee, Glasgow, Mont., will purchase one 50-kw., three-phase, 50-cycle, 2300-volt generator and some additional equipment. A. J. Melvin is superintendent.

The electric-light plant at the State Agricultural College, Jonesboro, Ark., which was recently destroyed by fire, will be rebuilt.

The city of Tucson, Ariz., contemplates purchasing two water-tube boilers for the water-works system, to cost about $8000. J. Moss Ruthrauff is city engineer.

The power plant of the Eastern Oregon Light & Power Co., at Baker, Ore. was recently destroyed by fire. Estimated loss, $75,000.

The Anaheim Union Water Co. will install a 150-hp. electric motor in its plant at Fullerton, Calif.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

WANTED FOR PANAMA CANAL, experienced erectors for the erection of lock machinery; salary, $140 month; free transportation from New York or New Orleans; must be American citizens (final papers), under 45 years, in sound physical condition. Write Panama Canal Office, Washington, D. C.

POSITIONS WANTED

MECHANICAL DRAFTSMAN, 13 years' experience on design and construction of steam stations, is open for engagement; 30 years of age, hustler and producer. P. W. 227, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

ENGINEER, technical graduate, 10 years' experience with large engines, Curtis, Parson and Rateau turbines, up to date on electrical and refrigerating machinery, formerly chief engineer in large hotel, would like to correspond with a firm where exceptional ability and low-power production is appreciated; can furnish first-class references from past and present employer. P. W. 228, Power.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

MISCELLANEOUS

PATENTS. C. L. Parker, patent attorney, 904 G St., Washington, D. C. Inventor's handbook sent upon request.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

ENGINE—16x36 Hewes & Phillips Corliss engine, entirely overhauled, fully guaranteed, $700. Duzets & Son, Hudson Terminal, New York.

BOILERS—Two 50-hp., 54-in. by 12-ft. return-tubular boilers, in excellent condition; will sell for $200 each f.o.b. cars Lockport, N. Y. F. S. 218, Power.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

ALTERNATOR—100 kw. General Electric revolving field, three-phase, 60-cycle, 250-volt, with exciter and switchboard, $600. Duzets & Son, Hudson Terminal, New York.

GENERATORS—75 kw. Crocker-Wheeler 250-volt generator, direct connected Harrisburg Fleming engine, with switchboard, $1200. Duzets & Son, Hudson Terminal, New York.

TURBINE GENERATING SET—300-kw. Westinghouse Parsons three-phase, 60-cycle, 220- or 440-volt turbine outfit, with condenser; practically new. George Sachsenmaier & Co., 143 North Third St., Philadelphia, Penn.

COCHRANE HEATER—One No. 3, rebuilt and in excellent condition, $95; one American steel plate blower, three-quarter housing, bottom horizontal discharge, 24-in. inlet, first-class shape, $65. The Arbuckle-Ryan Co., 224-34 Cherry St., Toledo, Ohio.

BOILERS—Battery of three 125-hp. horizontal tubular; insured 125 lb.; stack, 66 in. diameter, 90 ft. high, and breeching; manufactured by the E. Keeler Co.; cost, $3500 f.o.b. cars; will sell at bargain. McKenzie Mfg. Co., 765 North Ave., Plainfield, New Jersey.

PATENTS, PATTERNS, etc., for the simplest device for prevention of smoke on the market; this device is in successful operation; will sell outright, or on royalty basis; this device can be sold for less money and at a good profit than any other device on the market. F. S. 217, Power.